Eco

1.0 INTRODUCTION

1.1 Objective

There were three objectives incorporated into the investigation of contamination associated with the Cornell-Dubilier Electronics site in South Plainfield, New Jersey: 1) to investigate the nature and extent of contamination within the Bound Brook downstream of the Cornell-Dubilier Electronics site; 2) to conduct an ecological risk assessment of a portion of the Bound Brook and its associated floodplain downstream of the Cornell-Dubilier Electronics site, according to the Ecological Risk Assessment Guidance for Superfund (U.S. EPA 1997a); and 3) to collect and analyze fish fillets from the Bound Brook downstream of the Cornell-Dubilier Electronics site for the purposes of assessment of risk to human health.

1.2 Site Background

The Cornell-Dubilier Electronics Site is located at 333 Hamilton Boulevard in South Plainfield, Middlesex County, New Jersey (Figure 1). The site occupies approximately 25 acres in an industrial, commercial, and residential area. It is bordered by commercial businesses and residences from the south to the north, and wetlands and the Bound Brook from the southeast. Conrail railroad tracks crisscross the Bound Brook just north of the site. Other industries are scattered to the northeast and east of the site on the opposite side of the railroad tracks (U.S. EPA 1997b).

During its years of operation at the site (1936 to 1962), Cornell-Dubilier Electronics, Inc. manufactured electronic parts and components, including capacitors. It is reported that during that time, transformer oils were tested. It is alleged that Cornell-Dubilier Electronics, Inc. dumped polychlorinated biphenyl (PCB) contaminated materials and other hazardous substances directly onto site soils (U.S. EPA 1997b).

Historical aerial photographs reveal evidence that extensive filling operations were underway at the site in the 1940s, possibly to support construction of a railroad spur to the operating facility. A title search indicates that the Spicer Manufacturing Corporation, later known as Dana Corporation, owned the property during this period (U.S. EPA 1997b).

The site is currently known as the Hamilton Industrial Park and is occupied by approximately 15 commercial businesses. Through the years, dozens of companies have operated at the site as tenants (U.S. EPA 1997b). Currently, the property is secured by a fence with posted warning signs that were installed during the site stabilization removal action initiated in July 1997.

1.3 Site Description

It is estimated that approximately 540 persons reside within 0.25 miles of the site, with the nearest residential homes being located on Spicer Avenue and on the opposite side of Hamilton Boulevard, less than 200 feet from the site. The total population estimated to live within one mile of the site is 8,700 persons (U.S. EPA 1997b).

The Bound Brook traverses the southeast corner of the site property. Stream width varies from 10 to 20 feet across the site, with a varying depth of approximately 1 to 4 feet. The Bound Brook flows northwest for approximately 0.5 miles before joining the Cedar Brook (which drains Spring Lake to the northeast). The Bound Brook flows approximately 0.75 miles before emptying into the east end of New Market Pond. After flowing over a spillway at the west end of New Market Pond, the Bound Brook continues west for approximately four miles before joining with the Green Brook. The Green Brook continues southwest for another three miles before flowing into the Raritan River. All the previously mentioned water bodies are designated by the State of New Jersey for the maintenance, migration, and propagation of the natural and established biota. There are no surface water intakes along this flow path for at least 15 miles. However, these water bodies are reportedly utilized as freshwater fisheries (U.S. EPA 1997b).

As reported by the United States Environmental Protection Agency (U.S. EPA 1997b), there are approximately 34 acres of wetlands within 0.5 miles of the site. Wetlands that border the site to the southeast diminish significantly as the creek heads downstream toward the northwest.

An unknown source investigation conducted by the NJ Department of Environmental Protection (DEP) in the vicinity of Hamilton Boulevard during 1988 to 1991 revealed significant ground water contamination consisting of mainly trichloroethene (TCE) and tetrachloroethene (PCE). Samples collected from a shallow (70 feet) residential potable well located approximately 500 feet west of the site revealed TCE (6,850 micrograms per liter [μg/L]) and PCE (12.6 μg/L) contamination. Due to widespread contamination, all residential wells in the area were reportedly closed and residences were hooked up to a water main providing potable water from another location. Although the site was considered to be one of several potential sources, to date, the source of the contamination has not been identified (U.S. EPA 1997b).

2.0 TECHNICAL APPROACH

The results of the Screening Level Ecological Risk Assessment for the site prepared by the U.S. EPA Region II (1996), indicated that a field investigation was appropriate to collect additional site information. This involved the collection of soil, sediment, surface water, and biota. In addition to chemical analyses, selected sediment samples were also evaluated using toxicity tests.

A preliminary investigation (Phase I) was conducted between 28 and 30 May 1997 to determine the downstream extent of PCBs and metals in the sediment and floodplain soils using screening methods. These data [summarized in Bound Brook Sampling and Edible Fish Tissue Data Report (U.S. EPA 1997c)] were utilized to select sampling locations between the site and New Market Pond (Phase II). Phase II was conducted on 16 through 20 and 27 June 1997. Samples collected for Phase II included surface water, sediment, soil, small mammals, crayfish, forage fish, and edible fish (fillets). These data were used to support an ecological risk assessment, an extent of contamination evaluation, and a presentation of data for a human health risk assessment, which was performed by Region II U.S. EPA. Preliminary data from Phase II indicated that PCBs, as well as other contaminants, were detected in fish collected as far downstream as New Market Pond. Therefore, an additional round of sampling (Phase III) was conducted on 7 August 1997 to evaluate the downstream extent of contamination in the Bound Brook. Only edible fish tissue and sediments were collected during Phase III. To get fish of similar size and species composition, Spring Lake was utilized as a reference area for Phase III. All fish collections were performed in conjunction with U.S. EPA Region II Division of Environmental Science and Assessment under the direction of Jim Kurtenbach and Christopher Stitt.

The work performed for this investigation follows the methods summarized in the Work Plan (U.S. EPA 1997d) and the appropriate Standard Operating Procedures (SOPs) (see Section 2.10), with the exception that small mammals were not analyzed for Target Analyte List (TAL) metals. A copy of all field and laboratory documentation is contained in Appendix A. A description of the methods used for this investigation is provided next.

2.1 Preliminary Sampling - Phase I

Prior to the Phase II field investigation, preliminary soil and sediment sampling was conducted downstream of the Cornell-Dubilier Electronics site to the east end of New Market Pond. The objective of the preliminary sampling was to evaluate the downstream extent of PCB and metals contamination. The data were analyzed using gas chromatography/electron capture detection (GC/ECD) screening methods for PCBs and x-ray fluorescence (XRF) for metals. No validation of the data was performed, and data were considered as Quality Assurance Level 1 (QA-1) screening data. The results of the preliminary sampling were used to select sample locations for the Phase II investigation and are summarized in the

Bound Brook Sampling and Edible Fish Tissue Data Report (U.S. EPA 1997c).

2.2 Soil Sampling - Phase II

Replicate soil samples were collected from each of the four terrestrial sample areas (T1, T2, T3, and T4 [reference area]) (Figure 2). These samples were used to characterize the chemical concentrations in the soil for each of the four sample areas. The locations of the soil samples were randomly selected within the small mammal trapping grids (Section 2.8). Soil samples were analyzed for PCBs, pesticides, metals, volatiles, semivolatiles, grain size, and total organic carbon (TOC).

Soil samples were collected in accordance with the Environmental Response Team Center/Response Engineering and Analytical Contract (ERTC/REAC) SOP #2012, *Soil Sampling*. Soil was collected using a decontaminated stainless steel trowel or bucket auger to a depth of 6 inches. The soil within a 1.5 foot by 1.5 foot area was collected and deposited into a labeled 5-gallon decontaminated stainless steel bucket until sufficient sample volume was obtained for all required chemical analyses. The sample was transported to the staging area, mixed, and divided among the appropriate sample containers. Samples for volatile organic carbon (VOC) analyses were obtained from the bulk sample prior to mixing. The soil samples were maintained and shipped on wet ice prior to analysis.

2.3 Sediment Sampling - Phases II and III

For Phase II, two replicate sediment samples were collected from each of the eight sample locations: A1 (adjacent to the site), A2 (below Veterans Park), A3 (Clinton Avenue Bridge), A4 (New Brunswick Avenue Bridge), A5 (east New Market Pond), A6 (west New Mark Pond), A7 (below spillway), and A9 (upstream reference area). Aquatic sample locations for Phase II are specified in Figure 3. For Phase III, two replicate sediment samples were collected from each of the five sample locations: A11 (below spillway, same location as A7), A12 (Prospect Street Bridge), A13 (South Avenue Bridge), A14 (Lincoln Boulevard Bridge), and A10 (Spring Lake reference area). Aquatic sample locations for Phase III are specified in Figure 4. These samples were used to characterize the chemical concentrations in the sediment for each of the sample areas. Sediment samples were analyzed for PCBs, pesticides, metals, semivolatiles, volatiles, grain size, and TOC. At sample locations where toxicity tests were going to be performed (A1, A2, A3, A4, A5, A6, and A9), sediment samples were also analyzed for ammonia and total petroleum hydrocarbons (TPH).

Sediment samples were collected in accordance with ERTC/REAC SOP #2016, *Sediment Sampling*. Sediment samples were collected from a depositional area using a decontaminated Ponar dredge or stainless steel trowels and deposited into a stainless steel bucket until the volume was sufficient to meet analytical and toxicity testing volume requirements. The bulk sample was then covered and returned to the staging area. Samples for VOC analyses were taken from the bulk sample prior to homogenization. After the remaining sediment was homogenized, the sample was placed in appropriately labeled sample containers for chemical analyses and toxicity testing. The samples were maintained on wet ice until they were shipped to the specified laboratory via overnight courier for analysis.

2.4 Surface Water Sampling - Phase II

A surface water sample was collected from each of the eight aquatic sample locations (Figure 3). Surface water samples were analyzed for PCBs, pesticides, metals (total and dissolved), semivolatiles, and VOCs. Surface water samples could not be collected during the original week of the site investigation (16 through 20 June 1997) due to high turbidity levels caused by heavy rains. Surface water sampling was postponed until 27 June 1997.

Surface water samples were collected directly into the sampling container following ERTC/REAC SOP

#2013, *Surface Water Sampling*. Water samples were collected upstream of any river disturbances being caused by the sampler. The surface water samples being analyzed for dissolved metals were filtered prior to preservation and analysis. All samples were maintained and shipped on wet ice prior to analysis. Samples being analyzed for metals were preserved using 40 percent nitric acid to a pH of less than 2 units.

Water quality parameters were measured using a Horiba U-10. The water quality parameters evaluated included temperature, pH, dissolved oxygen, conductivity, turbidity, and salinity. The instrument was calibrated prior to data collection as per the manufacturer's operating manual.

2.5 Amphipod Toxicity Test - Phase II

The amphipod toxicity tests were subcontracted to a laboratory with documented experience of performing the test. The toxicity tests were fourteen days in duration and included six replicates per sample. Six sample locations adjacent to and downstream of the site (A1, A2, A3, A4, A5, A6); a reference location (A9); and a laboratory control were evaluated during this test. Each replicate contained twenty 2nd or 3rd instar amphipods. Toxicity was evaluated for 100 percent site sediment only; no sediment dilutions were used. Approximately 40 percent of the overlying water volume was replaced with laboratory water on days 2, 4, 6, 8, 10 and 12 in a way that minimized turbulence and disturbance of the sediment. Dissolved oxygen and pH were measured in each replicate immediately before and after each renewal. The organisms were fed periodically with a suitable food at a rate sufficient to support growth without resulting in fungal production. For the test to be considered valid, control mortality could not exceed 20 percent. The endpoints measured by the subcontract laboratory included mortality (percent mortality) and growth (total length). The toxicity test followed ERT/REAC DRAFT SOP, *10-Day Chronic Toxicity Test Using Amphipods (Hyalella azteca)*. Any deviation from the SOP was reported by the subcontract laboratory in the toxicity evaluation report.

Statistical comparisons were used to determine if there was a significant difference ($\alpha = 0.10$) in any of the measurement endpoints (e.g., growth, mortality) between either the laboratory control or a reference location and any of the on-site sample locations. A Dunnett's one-sided test was utilized for the analyses. If any of the assumptions required for the Dunnett's test was not met (i.e., normality and homogeneity of variances), a Dunnett's test on the ranks was used to provide a non-parametric, distribution-free comparison of the means.

If significant differences were observed between any of the sampling locations adjacent to the site and either the laboratory control or the upstream reference locations, the test species was considered to be impacted at that sample location. The impact may be related to exposure to contaminants or to differences in sediment matrices or physical characteristics. Correlation analyses were used to determine if the impacts were related to the concentrations of any contaminants or physical sample characteristics that were measured.

2.6 Fish Collection

2.6.1 Edible Fish - Phases II and III

Fish were collected in conjunction with U.S. EPA Region II from ten locations adjacent to and downstream of the site, an upstream reference area (A9) and Spring Lake (A10). Samples were collected from the Bound Brook, New Market Pond, Spring Lake, and Green Brook (below the confluence with the Bound Brook) using electrofishing techniques (Figures 3 and 4). Phase III (i.e., below New Market Pond) sampling was conducted as a result of the contaminant levels detected in the fillet tissue in Phase II.

The objective of the sampling was to collect edible-size bottom feeding fish (bullheads, carp, and white suckers) and predatory fish (sunfish and largemouth bass) of similar size between the sample locations. A maximum number of three replicates were collected for each species from each sample location but not all species were caught at all locations (e.g., bullheads were only collected at locations A5, A11, A12, and A14).

The sampling crew taxonomically identified the fish, measured the length and weight of the fish, and performed a gross pathology evaluation. The fish were prepared following the U.S. EPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (U.S. EPA 1993a). Fish were scaled prior to filleting. Each fillet sample represented a single fish; no sample compositing was required to meet analytical mass requirements. The fillets were weighed, wrapped in aluminum foil, placed in a plastic bag, and maintained on wet ice. Fish were delivered to the REAC Biological Assessment Laboratory in Edison, NJ for chemical analysis. Fish tissues were analyzed for metals, PCBs, pesticides, percent lipids, and percent moisture. The data will be used by Region II U.S. EPA for a human health risk assessment.

2.6.2 Forage Fish - Phase II

Forage fish were collected from six locations (A1, A2, A3, A4, A5, and A6) adjacent to and downstream of the site and from an upstream reference area (A9) using electrofishing. Based on electrofishing results, the sunfish (pumpkinseed at all locations except Spring Lake (A10) in which bluegills were used) were selected as the forage fish, as they were most consistently captured at each of the sample locations.

Captured fish were placed on wet ice and transported to the REAC Biological Assessment Laboratory, Edison, NJ. Up to eight replicates were collected from each of the sample locations. The digestive tracts were removed, and the fish were weighed and placed in aluminum foil. Fish were not composited; each sample represents a single fish. The fish were submitted to a subcontract laboratory for chemical analyses (PCBs, metals, pesticides, percent lipids). In some instances sunfish fillets were analyzed separately from the carcass so the fillet data could be used for the human health risk assessment. In these cases the fillet data and the carcass data were recombined to provide whole body concentrations (Appendix B). Voucher specimens for taxonomic identification were also collected and preserved in 2-propanol (isopropyl alcohol).

2.7 Crayfish Sampling - Phase II

Crayfish were collected from six locations (A1, A2, A3, A4, A5, A6) adjacent to and downstream of the site and from an upstream reference area (A9). Crayfish were collected using electrofishing and crayfish traps baited with cat food. The taxon and weight were determined for each specimen collected. All captured crayfish were placed in 2-gallon decontaminated plastic buckets (hereafter referred to as depuration chambers) per location and maintained live in reference water for depuration. Aeration was provided to each chamber with an aquarium air pump and air stone. The crayfish were allowed to depurate in this manner for 18 to 20 hours after capture to remove sediments entrained in the digestive tract.

Depending on trapping success, up to eight specimens were retained per location for chemical analyses (PCB, metals, pesticides, semivolatiles, and percent lipids). After the depuration, each specimen was sacrificed, weighed, measured, and wrapped in aluminum foil. Crayfish were only composited for laboratory quality assurance samples (i.e., matrix spikes) due to the larger mass requirements. Composited samples were identified with the suffix "COMP" and were only used for laboratory performance evaluation. The samples were placed on wet ice and shipped to the subcontract laboratory for whole body homogenization and analysis. Voucher specimens for taxonomic identification were collected and preserved in 2-propanol (isopropyl alcohol).

2.8 Small Mammals - Phase II

Small mammals were collected from four locations. Three of the locations (T1, T2, and T3) were adjacent to and down gradient of the site and the fourth location was the reference area (T4) (Figure 2). The intent of the trapping was to collect eight adult white-footed mice (*Peromyscus leucopus*) from each area (32 mammals total). All field trapping activities were conducted in accordance with ERT/REAC SOP #2029, *Small Mammal Sampling and Processing*.

Sampling was performed using Museum Special traps and Sherman traps set in grids. All traps were spaced 15 feet apart and baited with a rolled oats and peanut butter mixture. The traps were checked in the morning and evening for a maximum of a 3-night trapping period. Traps were rebaited as necessary. Recovered animals were labeled and stored on wet ice in coolers before processing. Trapping was terminated in each area once a sufficient number of specimens were collected. On the second day of trapping, a majority of the traps in the reference area (T4) had to be replaced and reset due to vandalism.

Specimens were then transported to the REAC Biological Assessment Laboratory, Edison, NJ, in coolers on wet ice for processing. The metrics recorded included total body weight, body length, tail length, ear length, liver weight, and kidney weight. Liver and kidney sections (approximately 0.5 g each) were taken for histopathological analysis and preserved in a labeled 40-milliliter (mL) glass vial filled with 10 percent buffered formalin. Gross necropsies were then conducted, and the gastrointestinal contents of each animal were removed (stomachs were emptied, rinsed with distilled water and returned).

After processing, up to eight specimens from each area were placed in labeled self-sealing plastic bags, and maintained on dry ice prior to being shipped to a subcontract laboratory for residue analyses. A whole body tissue homogenate was prepared and the frozen homogenate was submitted for PCB, pesticide, and percent lipid analyses.

Preserved liver and kidney sections from each specimen were submitted to a subcontract laboratory for histopathological evaluation. The histopathological results for each organism were related to both the contaminant concentrations measured in the tissue of that organism as well as in co-located soil samples.

2.9 Sampling Equipment Decontamination

The following sampling equipment decontamination procedure was employed prior to and subsequent to sampling each station in the following numerical sequence:

1 physical removal
2 nonphosphate detergent wash
3 potable water and distilled water rinse
4 10 percent nitric acid rinse
5 solvent rinse [acetone]
6 distilled water rinse
7 air dry

2.10 Standard Operating Procedures (SOPs)

2.10.1 Documentation

Documentation was completed as per the following SOPs:

- ERT/REAC SOP #2002, *Sample Documentation*
- ERT/REAC SOP #4001, *Logbook Documentation*
- ERT/REAC SOP #4005, *Chain of Custody Procedures*

2.10.2 Sample Packaging, Shipment, Storage, Preservation, and Handling

Sample packaging, shipment, storage, preservation and handling were conducted in accordance with the following SOPs:

- ERT/REAC SOP #2003, *Sample Storage, Preservation and Handling*
- REAC SOP #2004, *Sample Packaging and Shipment*

2.10.3 Field Sampling and Analytical Techniques

Field sampling activities and field analyses were conducted in accordance with the following SOPs:

- ERT/REAC SOP #2001, *General Field Sampling Guidelines*
- ERT/REAC SOP #2005, *Quality Assurance/Quality Control Samples*
- ERT/REAC SOP #2006, *Sampling Equipment Decontamination*
- ERT/REAC SOP #2012, *Soil Sampling*
- ERT/REAC SOP #2013, *Surface Water Sampling*
- ERT/REAC SOP #2016, *Sediment Sampling*
- REAC SOP #2019, *Surface Geophysics*
- ERT/REAC DRAFT SOP, *10-Day Chronic Toxicity Test Using Amphipods (Hyalella azteca)*
- REAC DRAFT SOP #2029, *Small Mammal Trapping and Processing*

2.10.4 Health and Safety

Health and Safety was conducted in accordance with the following SOPs:

- REAC SOP #3001, *REAC Health and Safety Program Policy and Implementation*
- REAC SOP #3012, *REAC Health and Safety Guidelines at Hazardous Waste Sites*
- REAC SOP #3001, *Inclement Weather, Heat Stress and Cold Stress*

3.0 RESULTS

3.1 General Information and Case Narrative

Tables 1A and 1B contain a summary of the analytical and biological parameters that were evaluated at each sample location. For Phase II, the results are summarized for surface water samples in Tables 2 through 6; sediments in Tables 7 through 14; soils in Tables 15 through 20; biota in Tables 21 through 26; edible fish tissue (fillet data) in Tables 27 and 28; and the toxicity test in Table 29. For Phase III, the results of sediments are summarized in Tables 30 through 35 and edible fish tissue (fillet data) are summarized in Tables 36 and 37. In general, all concentrations were reported in milligrams per kilogram (mg/kg). Abiotic (soil and sediment) samples are discussed next on a dry weight basis. Biotic samples are then discussed on a wet weight basis. For the purposes of the ecological risk assessment, abiotic data are also presented in the tables on a wet weight basis. The dry weight concentration data tables for each matrix or set of samples are followed by the corresponding wet weight data tables. Any exceptions to this are stated in the respective results sections.

The data tables contain summary data only. Compounds that were not detected in any of the samples (on a per matrix basis) are not included in the tables. A complete summary of all analytical data, detection limits, quality assurance/quality control (QA/QC) evaluations, and methods are contained in the Analytical Reports (Appendix C)

Next is a summary of the data qualifiers that were used by data validators to flag non-routine analyses or results. This summary contains a broad overall discussion of general data validation qualifications. A complete summary of all data validation issues is contained in the case narrative in each of the Analytical Reports (Appendix C). The qualifiers are standard protocol for all data evaluated by REAC.

Organic compounds that were detected in the laboratory method blank were subjected to a set of criteria for establishing the validity of any detected values in the site samples and field/trip blanks. For example, if a compound was detected in the laboratory method blank, hereafter referred to as the method blank, any detected values in the site samples and field/trip blanks for that compound were considered to be not detected unless these detected values exceeded five times the value detected in the method blank. An exception to this criteria exists for those compounds considered to be common laboratory contaminants (e.g., acetone and methylene chloride). If acetone and methylene chloride were detected in the method blank, any detected values of acetone and methylene chloride in the site samples and field/trip blanks were considered to be not detected unless these detected values exceeded ten times the value detected in the method blank. The values that did not meet these criteria were subsequently replaced in the data tables with the designation "B".

The inorganic data were subjected to similar criteria but on a compound- and case-specific basis. The recommendations presented in the REAC Final Analytical Report case narrative (Appendix C) were followed for designating results as estimated values. These values appear in the tables and are designated with the letter "J".

The designation "J" was also used in the organic and inorganic data set for those values that were below the method detection limit, but were positively identified as the compound in question. These values are considered to be estimates. In the case of PCBs, the analytical results suggest the occurrence of compound weathering or biodegradation. This means that although the proportions of the Aroclor mixture components may differ from the laboratory standards, these compounds were positively identified as Aroclor mixtures. These values were designated with the letter "W".

Samples that were extracted and/or analyzed outside the holding time were designated as "J" or estimated values. Compounds that were associated with surrogates, matrix spikes, or standards that were outside the specified quality control (QC) limits were also designated as "J" or estimated values. At the data validator's discretion, a few base-, neutral-, and acid-extractable (BNA) compounds (e.g., benzidine) in a few of the samples were completely out of range and the data were considered unusable.

Pentachlorophenol (PCP) was detected in two crayfish samples (A3-12 and A5-3). The subcontract laboratory reported problems with delayed elution of PCP and the GC columns were subsequently repacked with new separation beads. The PCP detected in these samples was carried over from matrix spikes and these data are considered unusable.

For inorganic analytes, if the analyte was not detected in a sample, a value of one-half the detection limit was utilized in the ecological risk assessment. For all organic compounds, if the analyte was not detected in a sample, a value of one-tenth the detection limit was utilized in the ecological risk assessment. For organic compounds, detected concentrations that were below the detection limit are reported with a qualifier ("J") to indicate that these are estimated values. For inorganic analytes, values below the detection limit are not reported.

All samples were maintained following chain-of-custody procedures. All Chain-of-Custody forms and field data sheets are contained in Appendix A (Field and Laboratory Documentation).

3.2 Preliminary Sampling (Phase I)

The results of the preliminary sampling were used to evaluate the extent of PCB and metal contamination downstream and down gradient of the Cornell-Dubilier Electronics site (U.S. EPA 1997c). Based on the chemical concentrations in the soil and sediments, it was determined that PCB contamination extended from the site to the east end of New Market Pond. The PCB (Aroclor 1254) concentrations were up to 13 mg/kg, wet weight (ww) in the sediment and up to 6.2 mg/kg, ww, in the flood plain soils (U.S. EPA 1997c). Copper, zinc, lead and barium were also detected in soil and sediment samples at concentrations up to 210, 620, 540, 380 mg/kg, ww, respectively. These data were used to select sampling locations for the Phase II investigation.

3.3 Data Collected Above New Market Pond (Phase II)

3.3.1 Results of In-situ Water Quality Parameters

Water quality measurements, including temperature, pH, conductivity, turbidity, dissolved oxygen, and salinity were measured at each sample station. Water quality data are summarized in Table 2. In general, water temperature, pH, turbidity, and dissolved oxygen were higher and conductivity was lower in the downstream (west) end of New Market Pond (A6) and just below the spillway dam at the downstream end of New Market Pond (A7) compared to the upstream (east) end of New Market Pond (A5) and the Bound Brook (A1 through A4 and A9). In the downstream end of New Market Pond and just below the spillway, temperature ranged from 27.7 to 28.8 °C. In the Bound Brook and at the upstream end of New Market Pond, temperature ranged from 23.6 to 27.0 degrees Celsius (°C). The surface water at each of the sample stations was slightly alkaline with pH measurements of 8.1 and 8.5 units in the downstream end of New Market Pond and just below the spillway and from 7.4 to 7.7 in the upstream end of New Market Pond and in the Bound Brook. Turbidity ranged from 25 to 30 Nephelometric Turbidity Units (NTU) in the downstream end of New Market Pond and just below the spillway and from 0 to 16 NTU in the upstream end of New Market Pond and in the Bound Brook. Samples collected from the downstream end of New Market Pond and just below the spillway were saturated or nearly saturated with dissolved oxygen (7.60 to 10.15 milligrams per liter [mg/L]) while sample stations in the upstream end of New Market Pond and in the Bound Brook had lower dissolved oxygen concentrations (2.54 to 6.37 mg/L). Salinity was low (≤0.02 parts per thousand [ppt]) at all sample locations. All surface water sampling and water quality evaluations were performed during dry weather conditions and at normal seasonal water levels.

3.3.2 Results of Chemical Analysis of Surface Water

3.3.2.1 VOCs

Five VOCs (methyl tert butyl ether; 1,1,2,2-tetrachlorethane; cis-1,2-dichloroethene; trans-1,2-dichloroethene; and trichloroethene) were detected in low levels in the surface water samples (Table 3). Only one compound at one location exceeded the method detection limit: at location A5 trichloroethene was detected at a concentration of 0.005 mg/L. Methyl tert butyl ether was only detected at two sample stations: the reference location (A9) and the sample collected adjacent to the site (A1). The remaining four VOC compounds were only detected at sample locations A5 and A6.

3.3.2.2 BNAs

Three BNA compounds [bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and diethylphthalate] were detected at concentrations below the method detection limit at location A6 (Table 4). No BNA compounds were detected at any of the other sample locations.

3.3.2.3 Metals

Thirteen TAL metals (aluminum, barium, calcium, chromium, copper, iron, potassium, magnesium, manganese, sodium, nickel, lead, vanadium, and zinc) were detected in the filtered and unfiltered surface water samples (Tables 5 and 6). For aluminum and iron, the filtered samples contained nondetectable and/or much lower concentrations compared to the unfiltered samples indicating that a major fraction of the analyte was associated with suspended particles. For barium, calcium, potassium, magnesium, and sodium the opposite of this occurred, indicating that a major fraction of these analytes was dissolved in the water column. Lead, vanadium, and zinc appear to be equally split between the dissolved and suspended fractions of the water column. Neither copper nor chromium were detected in enough of the samples or at high enough concentrations to determine whether they were associated with suspended particles or dissolved in the water column.

3.3.2.4 Pesticide/PCBs

No pesticides or PCB compounds were detected in any of the surface water samples. The detection limits for Aroclor 1254 ranged from 0.0010 to 0.0011 mg/L for detection limits for other pesticide or PCB Aroclors (Appendix C).

3.3.3 Results of Chemical Analysis of Sediments

3.3.3.1 VOCs

Twelve VOCs were detected in the sediment samples (Table 7). Excluding methylene chloride, which is a common laboratory contaminant and was detected in some of the laboratory blank samples, and acetone, which was used for sample equipment decontamination, only one compound (toluene) was detected in more than two samples. Toluene concentrations ranged up to 1.9 mg/kg and were detected in at least one sample from four of the eight sample locations. The remaining VOCs were detected at low concentrations (less than 0.1 mg/kg) and many (1,1,1-trichloroethane, chloroethane, 2-hexanone, carbon disulfide, p-isopropyltoluene, n-butylbenzene, naphthalene, and 1,2,3-trichlorobenzene) were detected only in single samples.

3.3.3.2 BNAs

Twenty-three BNA compounds were detected in the sediment samples (Table 8). Ten of the twenty-three compounds (benzidine, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, and benzo(ghi)perylene) were detected at every sample location (including the reference area, A9). One of the BNA compounds, bis (2-ethyl) phthalate, was not considered to be a site-related contaminant since it was detected in the blank samples and is a common laboratory contaminant. Total BNA concentrations ranged from 0.28 mg/kg in sample A5-2 to 170 mg/kg in sample A5-1. Excluding phalates, benzidine was the compound that was found at the highest levels in the samples. Benzidine was detected in all the samples except A5-2 (which overall had the lowest total PAH concentration) at concentrations up to 81 mg/kg. Benzidine, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, and benzo(ghi)perylene were the most frequently detected compounds at concentrations between 0.5 and 5 mg/kg in most samples.

Samples collected adjacent to the site (Area A1) contained the maximum levels of 2,6 dinitrotoluene (A1-2, 0.47 mg/kg), butyl benzyl phthalate (A1-4, 14 mg/kg), and bis (2-

ethylhexyl)phthalate, 170 mg/kg). Sample A2-1 contained the maximum concentrations of benzoic acid (0.57 mg/kg) and naphthalene (0.23 mg/kg). Sample A3-1 contained the maximum concentration of di-n-octyl phthalate (35 mg/kg). The remaining sixteen compounds were detected at maximum concentrations in sample A5-1 at concentrations between 0.26 and 81 mg/kg.

3.3.3.3 Metals

The metal results are summarized in Table 9.1 and Table 9.2 for dry weight and wet weight concentrations, respectively. For all analytes except lead, the maximum concentrations were detected in samples from either location A1 or A6. Samples collected adjacent to the site (location A1) had the highest detected concentrations of aluminum (17,000 mg/kg), arsenic (13 mg/kg), barium (420 mg/kg), beryllium (1.2 mg/kg), calcium (7,200 mg/kg), cadmium (23 mg/kg), iron (36,000 mg/kg), potassium (1,300 mg/kg), magnesium (5,600 mg/kg), manganese (1,100 mg/kg), sodium (480 mg/kg), nickel (52 mg/kg), antimony (3.5 mg/kg), selenium (3.8 mg/kg), and vanadium (58 mg/kg). For calcium, the same maximum concentration was detected in a sample from location A3. For arsenic and selenium, the same maximum concentrations were also detected in samples from location A6. In addition to arsenic and selenium, the metals whose maximum concentrations were detected in samples from location A6 were mercury (0.91 mg/kg), silver (11 mg/kg), cobalt (21 mg/kg), chromium (78 mg/kg), copper (220 mg/kg), and zinc (670 mg/kg). For silver, the same maximum concentration was also detected in a sample from location A3. Lead was detected at the highest concentration (350 mg/kg) at location A4.

3.3.3.4 Pesticide/PCBs

Two pesticides (dieldrin and 4,4'-DDD) and one PCB (Aroclor 1254) were detected in the sediment samples (Table 10.1 in dry weights and Table 10.2 in wet weights). 4,4'-DDD was only detected in one sample A7-1 at an estimated concentration of 0.03 mg/kg. Dieldrin was detected in three samples from two locations (A3 and A7). Location A3 contained estimated dieldrin concentrations of 0.30 and 0.19 mg/kg in samples A3-1 and A3-2, respectively. Location A7 contained an estimated dieldrin concentration of 0.02 mg/kg in sample A7-1. Aroclor 1254 was detected at locations A1, A2, A5, and A6. Aroclor 1254 was detected at the highest concentrations in both samples collected at location A2 (14 mg/kg). The six samples collected at location A1 had Aroclor concentrations ranging from non-detect to 4.5 mg/kg ($\overline{X}$ = 2.2 mg/kg). Samples collected from locations A5 and A6 had mean Aroclor 1254 concentrations of 2.8 and 3.4 mg/kg, respectively.

3.3.3.5 Ammonia

Ammonia was detected in all samples at concentrations ranging from 85 mg/kg at location A9 to 670 mg/kg at location A6 (Table 11).

3.3.3.6 TPH

Total petroleum hydrocarbons were detected in all samples at concentrations ranging from 45 mg/kg at location A5-2 to 820 mg/kg at location A4-1 (Table 12).

3.3.3.7 Grain Size

The grain size results including gravel, sand, silt, and clay fractions and soil families are summarized in Table 13. Grain sizes were highly variable between sample locations although in general samples were composed primarily of sand and/or silt. All samples contained less than 40 percent clay and less than 1 percent gravel.

3.3.3.8 TOC

The TOC content of the sediments was highly variable and ranged from 3.07 percent in sample A5-2 to 22.4 percent in sample A6-2 (Table 14).

3.3.4 Results of Chemical Analysis of Soils

3.3.4.1 VOCs

Six VOCs were detected in low levels in the soil samples (Table 15). Two of the six VOCs, acetone and methylene chloride, were not considered to be field related contaminants. Acetone was used for sample equipment decontamination and methylene chloride was detected in the blank samples and is a frequent laboratory contaminant. Trichlorofluoromethane was detected in samples from each of the four sampling locations at concentrations up to 0.05 mg/kg. The remaining three compounds (1,1,1-trichloroethane, toluene, and trichloroethene) were detected in two or fewer samples at estimated concentrations up to 0.01 mg/kg.

3.3.4.2 BNAs

Thirty-four BNA compounds were detected in the soil samples (Table 16). Two of the BNA compounds, bis(2-ethylhexyl)phthalate and di-n-butylphthalate, were not considered to be site contaminants since they were both detected in the blank samples and are common laboratory contaminants. Fourteen of the BNA compounds (anthracene, benzo(k)fluoranthene, benzoic acid, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, benzo(ghi)perylene, butylbenzylphthalate, and naphthalene) were detected at every sample location (including the reference area, T4). In addition to these fourteen BNA compounds being frequently detected they also tended to be found in the highest concentrations, typically with concentrations ranging from 0.5 to 11 mg/kg for each compound.

Total BNA concentrations ranged from 3.3 mg/kg in sample T1-14-3 to 110 mg/kg in sample T1-11-9. Benzidine was not included in the calculation of total BNAs, because benzidine data were only available for four of the twenty-six samples. In the other samples benzidine concentrations were regarded as unusable during data validation. Incorporating benzidine in total BNA concentrations would have skewed the relative total BNA concentrations for area comparisons since benzidine represented between 58 and 216 percent of the total BNAs in these four samples. Areas T1 and T4 had the highest mean total BNA concentrations, 35 mg/kg and 31 mg/kg. Locations T2 and T3 both had mean total BNA concentrations of 18 mg/kg. With the exception of area T2 (coefficient of variation [cv] = 0.15), total BNA concentrations were extremely variable (cv = 0.88 to 1.09) between the samples collected in each area.

3.3.4.3 Metals

The metal results for soils are summarized in Table 17.1 and Table 17.2 for dry weight and wet weight concentrations, respectively. Thallium was the only analyte that was not detected in every sample. The highest concentrations of arsenic, barium, and sodium were detected in samples collected from area T1. The highest concentrations of silver, aluminum, beryllium, cadmium, cobalt, chromium, potassium, and manganese were detected in samples collected from area T2. The highest concentrations of mercury, calcium, copper, iron, nickel, lead, antimony, selenium, thallium, and zinc were detected in samples collected from area T3. The highest concentrations of magnesium and vanadium were detected in samples collected from area T4. Due to the high variability of soil metal concentrations within sample areas, area means were calculated and evaluated. When evaluating mean metal concentrations for all samples collected in each area, the highest mean concentrations of silver and manganese were detected in area T2 and the highest mean concentrations of mercury, nickel, arsenic, barium, copper, lead, antimony, selenium, and zinc were detected in area T3.

3.3.4.4 Pesticide/PCBs

Two pesticide compounds (heptachlor and 4,4' DDE) and Aroclor 1254 were detected in the soil samples (Table 18.1 and 18.2 for dry weight and wet weight concentrations, respectively). Aroclor 1254 was detected in all the samples collected from areas T1, T2, and T4 but was not detected in any of the samples collected from area T3. Heptachlor was detected in one sample (T3-1-13) from area T3; 4,4' DDE was detected in two samples (T3-1-13 and T3-2-11) from area T3. Area T1 contained the highest mean Aroclor 1254 concentrations (170 mg/kg) followed by areas T2 (39 mg/kg) and T4 (7.5 mg/kg). Variability in concentrations of Aroclor 1254 within each sample area was high with coefficient of variations ranging from 0.41 in area T2 to 1.24 in area T1.

The presence of Aroclor 1254 in the soil samples collected from area T4 demonstrates the possibility that area T4 is located within the floodplain of the Bound Brook. However, the mean concentration of Aroclor 1254 detected in the soil samples from area T4 (7.5 mg/kg) was much lower than the mean concentrations detected in the samples from areas T1 (170 mg/kg) and T2 (39 mg/kg). This indicates that the selection of area T4 as a reference area for the terrestrial locations was reasonable given the fact that there was no suitable county or municipal land up gradient of the site along the Bound Brook.

3.3.4.5 Grain Size

The grain size results including gravel, sand, silt, and clay fractions and soil families are summarized in Table 19. Grain sizes were highly variable between sample locations although in general, samples were dominated by sand and/or silt. Samples collected from areas T1 and T3 contained primarily sand while samples collected from locations T2 and T4 contained primarily silt.

3.3.4.6 TOC

The TOC content of the soils was highly variable and ranged from 7.0 percent in sample T1-1-4 to 45.3 percent in sample T4-4-1 (Table 20).

3.3.5 Results of Chemical Analysis of White-Footed Mice

3.3.5.1 Pesticide/PCBs

Four pesticide/PCB compounds, Aroclor 1254, heptachlor epoxide, dieldrin, and 4,4'-DDE, were detected in white-footed mice (*Peromyscus leucopus*) collected during this investigation (Table 21). Aroclor was detected in all the white-footed mice collected from areas T1, T2, and T4 and 50 percent of the white-footed mice collected from area T3. Mice collected from area T1 contained the highest overall Aroclor 1254 concentrations ($\overline{x}$ = 3.3 mg/kg; cv = 0.51; range = 0.63 to 5.4 mg/kg). Mice collected from areas T2 and T4 Aroclor contained lower PCB body burdens (Area T2, $\overline{x}$ = 0.80 mg/kg; cv = 0.69; range = 0.24 to 1.8 mg/kg; area T4 $\overline{x}$ = 0.72 mg/kg; cv = 0.57; range = 0.31 to 1.4 mg/kg). Aroclor 1254 was detected less frequently in the mice captured from area T3 and at lower concentrations than the other three areas ($\overline{x}$ = 0.14 mg/kg; cv = 1.2; range = ND to 0.44 mg/kg).

Compared to the PCBs, the three pesticides were detected less frequently and at lower concentrations. Dieldrin was detected in 60 percent of the mice collected in area T1 ($\bar{X}$ = 0.021 mg/kg; cv = 1.1; range = ND to 0.06 mg/kg), 43 percent of the mice collected in area T2 ($\bar{X}$ = 0.0073 mg/kg; cv = 1.2; range = ND to 0.02 mg/kg), 38 percent of the mice collected from area T4 ($\bar{X}$ = 0.0075 mg/kg; cv = 1.2; range = ND to 0.02 mg/kg) and none of the mice collected in area T3. Heptachlor epoxide was detected in two mice (T4-1-27 and T4-2-23) collected in area T4 at concentrations of 0.02 and 0.07 mg/kg, respectively. 4,4'-DDE was only detected in one mouse collected in area T1 (T1-9-7) at a concentration of 0.06 mg/kg.

3.3.6 Results of Chemical Analysis of Crayfish

3.3.6.1 BNAs

Four BNA compounds were detected in crayfish samples (Table 22). The BNA compounds detected in the crayfish included three phthalates [di-n-butylphthalate, bis(2-ethylhexyl)phthalate, and diethylphthalate] and isophorone. Bis (2-ethylhexyl)phthalate was detected in all of the crayfish collected at concentrations ranging from 0.25 to 0.80 mg/kg. Di-n-butylphthalate was detected in all of the samples except one at concentrations ranging from ND to 1.9 mg/kg. This compound was also detected in several of the laboratory blank samples at lower concentrations. Diethylphthalate was only detected in one crayfish (A5-1) at a concentration of 0.83 mg/kg. Isophorone was also only detected in one sample (A9-3) at a concentration of 0.40 mg/kg.

PCP was detected in two crayfish samples (A3-12 and A5-3). The subcontract laboratory reported problems with delayed elution of PCP, and the GC columns were subsequently repacked with new separation beads. The PCP detected in these samples was carried over from matrix spikes and is considered unusable.

3.3.6.2 Metals

Twenty TAL metals were detected in crayfish samples (Table 23). The highest mean tissue residue concentrations for mercury ($\bar{X}$ = 0.02 mg/kg), aluminum ($\bar{X}$ = 39 mg/kg), barium ($\bar{X}$ = 58 mg/kg), and lead ($\bar{X}$ = 1.3 mg/kg) was at location A9; iron ($\bar{X}$ = 120 mg/kg) at location A1; cadmium ($\bar{X}$ = 0.89 mg/kg), calcium ($\bar{X}$ = 32,000 mg/kg), copper ($\bar{X}$ = 53 mg/kg), potassium ($\bar{X}$ = 2,700 mg/kg), magnesium ($\bar{X}$ = 440 mg/kg), manganese ($\bar{X}$ = 130 mg/kg), and sodium ($\bar{X}$ = 2,000 mg/kg) at location A2; silver ($\bar{X}$ = 1.1 mg/kg) and vanadium ($\bar{X}$ = 0.25 mg/kg) at location A3; and arsenic ($\bar{X}$ = 0.58 mg/kg), cobalt ($\bar{X}$ = 0.22 mg/kg), nickel ($\bar{X}$ = 0.34 mg/kg), selenium ($\bar{X}$ = 0.93 mg/kg), and zinc ($\bar{X}$ = 25 mg/kg) at location A5. The frequency of detection ranged from over 80 percent for silver, barium, calcium, copper, iron, potassium, magnesium, manganese, sodium, lead, and zinc to less than 10 percent for arsenic, beryllium, chromium, antimony, and thallium.

3.3.6.3 Pesticide/PCBs

Aroclor 1254 was the only pesticide or PCB Aroclor detected in the crayfish samples (Table 24). Aroclor 1254 was detected in all of the crayfish samples from areas A1, A2, A3, A4, and A5 and only one sample (10 percent) from area A9, although that sample contained the third highest Aroclor 1254 concentration (2.2 mg/kg) detected in all of the samples. Area A2 had the highest mean PCB concentration ($\bar{X}$ = 1.8 mg/kg; cv 0.25; range = 1.1 to 2.4 mg/kg) followed by area A3 ($\bar{X}$ = 1.3 mg/kg; cv = 0.30; range = 0.88 to 1.8 mg/kg), area A4 ($\bar{X}$ = 1.2 mg/kg; cv = 0.26; range = 0.81 to 1.4 mg/kg), area A5 ($\bar{X}$ = 0.77 mg/kg; cv = 0.38; range = 0.55 to 1.1), area A1 ($\bar{X}$ = 0.75 mg/kg; cv = 0.66; range = 0.4 to 1.1 mg/kg), and area A9 ($\bar{X}$ = 0.24 mg/kg; cv = 2.83; range = ND to 2.2). The highest Aroclor 1254 concentration detected in a single crayfish sample was 2.4 mg/kg in sample A2-3.

3.3.7 Results of Chemical Analysis of Sunfish (Forage Fish)

3.3.7.1 Metals

Twenty TAL metals were detected in sunfish samples (Table 25). The only TAL metal not detected in any of the forage fish samples was thallium. The highest mean levels of mercury ($\bar{x}$ = 0.056 mg/kg; cv = 1.21), silver ($\bar{x}$ = 0.15 mg/kg; cv = 0.57), cadmium ($\bar{x}$ = 0.11 mg/kg; cv = 1.11), potassium ($\bar{x}$ = 2,800 mg/kg; cv = 0.036), manganese ($\bar{x}$ = 12 mg/kg; cv = 0.59), sodium ($\bar{x}$ = 1,700 mg/kg; cv = 0.92), vanadium ($\bar{x}$ = 0.26 mg/kg; cv = 0.16), and zinc ($\bar{x}$ = 0.26 mg/kg; cv = 0.27) were detected in area A1. The highest mean levels of alumium ($\bar{x}$ = 25 mg/kg; cv = 0.67) and iron ($\bar{x}$ = 37 mg/kg; cv = 1.07) were detected in area A3. The highest mean levels of copper ($\bar{x}$ = 1.4 mg/kg; cv = 0.48) and nickel ($\bar{x}$ = 0.28 mg/kg; cv = 1.07) were detected in area A4. The highest mean level of barium ($\bar{x}$ = 2.5 mg/kg; cv = 0.26) was detected in area A5. The highest mean levels of arsenic ($\bar{x}$ = 0.096 mg/kg; cv = 1.86), calcium ($\bar{x}$ = 19,000 mg/kg; cv = 0.15), chromium ($\bar{x}$ = 0.66 mg/kg; cv = 0.57), magnesium ($\bar{x}$ = 480 mg/kg; cv = 0.10), and lead ($\bar{x}$ = 0.68 mg/kg; cv = 1.32) were detected in area A6. The highest mean levels of antimony ($\bar{x}$ = 0.372 mg/kg; cv = 0.96) and vanadium ($\bar{x}$ = 1.32 mg/kg; cv = 0.17) were detected in the reference area (A9).

3.3.7.2 Pesticide/PCBs

Aroclor 1254 was the only pesticide or PCB Aroclor detected in the whole body sunfish samples (Table 26). Aroclor 1254 was detected in all the sunfish samples from all areas. Area A2 had the highest mean PCB concentration ($\bar{x}$ = 12 mg/kg; cv = 0.46; range = 7.1 to 20 mg/kg) followed by area A3 ($\bar{x}$ = 7.7 mg/kg; cv = 0.62; range = 3.3 to 15 mg/kg), area A4 ($\bar{x}$ = 6.3 mg/kg; cv = 0.73; range = 1.3 to 16 mg/kg), area A5 ($\bar{x}$ = 5.5 mg/kg; cv = 0.69; range = 2.1 to 11 mg/kg), area A1 ($\bar{x}$ = 3.9 mg/kg; cv = 1.39; range = 1.1 to 15 mg/kg), area A6 ($\bar{x}$ = 3.5 mg/kg; cv = 0.68; range = 0.9 to 7.6 mg/kg), and area A9 ($\bar{x}$ = 0.38 mg/kg; cv = 0.48; range 0.21 to 0.64 mg/kg). The maximum Aroclor 1254 concentration detected in a single sunfish sample was 20 mg/kg in sample A2-PS-1.

3.3.8 Results of Chemical Analysis of Fillet Samples

3.3.8.1 Metals

The results for TAL metal concentrations in edible fish tissue are summarized in Table 27. The metal results are discussed in conjunction with Phase III data in additional detail in Section 3.4.2.1.

3.3.8.2 Pesticide/PCBs

Aroclors 1248 and 1254 were detected in all fillet samples in all species (Table 28). Generally, Aroclor 1254 was detected at higher concentrations than Aroclor 1248. Aroclor 1254 concentrations ranged up to 26.0 mg/kg in carp, 12.0 mg/kg in white sucker, 5.0 mg/kg in sunfish, and 1.7 mg/kg in bass. Aroclor 1248 ranged up to 10.0 mg/kg in carp, 3.8 mg/kg in white sucker, 2.0 in sunfish, and 0.6 in bass.

Seven pesticides were also detected in the fillet samples (Table 28). These compounds were detected less frequently and in lower concentrations than the PCBs. Heptachlor epoxide was detected in 84 percent of the samples at a maximum concentration of 0.1 mg/kg. 4,4'-DDE was detected in 73 percent of the samples at a maximum concentration of 0.3 mg/kg. 4,4'-DDD, endrin aldehyde, g-chlordane, and a-chlordane were all detected in between 12 and 18 percent of the samples and at maximum concentrations of 0.2 mg/kg, 0.1 mg/kg, 0.2 mg/kg, and 0.3 mg/kg, respectively. Methoxychlor was only detected in one sample at a concentration of 0.004 mg/kg and was most likely a laboratory contaminant since it was also detected in the blank samples. The pesticide and PCB results are discussed in conjunction with Phase III data in additional detail in Section 3.4.2.2.

It should be noted that the frequency of detection of Aroclor 1248 and many of the pesticides was much greater for the fillet samples than for the sunfish carcass and whole body samples (Section 3.3.7.2). There are a variety of potential reasons for this, all of which stem from the fact that the fillet samples were analyzed at the REAC Analytical Laboratory in Edison, NJ, and the carcass and whole body samples were analyzed at a subcontract laboratory. First, the detection limits at the REAC laboratory were lower overall than those at the subcontract laboratory. Therefore, Aroclor 1248 and many pesticides were detected much more frequently in the fillets than in the sunfish carcass and whole body samples. Second, there was evidence that the PCBs were weathered in the samples, resulting in a large amount of individual discretion in the interpretation of the analytical chromatograms to distinguish between the various Aroclors (e.g., Aroclor 1254 vs. Aroclor 1248). Finally, as in any study in which two separate laboratories are utilized, interlaboratory variability may also play a small role in the differences in concentrations between the fillet samples and the whole body and carcass samples.

3.3.9 Results of Amphipod Toxicity Test

The survival and growth results of the 14-day solid phase amphipod (*Hyalella azteca*) toxicity test are contained in Table 29. Mean survival ranged from 76.7 percent at location A3 to 94.2 percent at location A2. Performance control survival was 83.3 percent which exceeds the U.S. EPA and American Society of Testing and Materials (ASTM) minimum criteria of 80 percent. Location A3 was the only location that was significantly different from the reference location (A9).

Mean amphipod length at the end of the test ranged from 2.4 millimeters (mm) at locations A9 and A4 to 2.8 mm at locations A1 and A2. No lengths were found to be significantly different from either the reference location (A9) or the laboratory control. A complete summary of all toxicity test results are contained in Appendix D.

3.4 Data Collected Below New Market Pond (Phase III)

3.4.1 Results of Chemical Analysis of Sediments

3.4.1.1 VOCs

Six VOCs (acetone, methyl-tertiary-butylether, 2-butanone, 1,2-dichloroethane, toluene, and p-isopropyltoluene) were detected in the sediment samples (Table 30). Acetone, which was used in sample equipment decontamination, was found in 50 percent of the samples (n = 5) at concentrations of up to 0.03 mg/kg. Five of the six VOCs (acetone, methyl-tertiary-butylether, 2-butanone, toluene, p-isopropyltoluene) were detected in samples from location A10. Four of the six VOCs (acetone, methyl-tertiary-butylether, 2-butanone, and p-isopropyltoluene) were detected in samples from location A11. Three of the six VOCs (acetone, 2-butanone, and 1,2-dichloroethane) were detected in samples from location A11. No VOCs were detected in any of the samples collected at locations A12 and A14. The maximum concentration of any VOC detected in a sediment sample was toluene at 0.09 mg/kg in sample A10-2. All other compounds (excluding acetone) were detected at concentrations at or below 0.01 mg/kg.

3.4.1.2 BNAs

Fifteen BNA compounds were detected in the sediment samples (Table 31). Three of the fifteen compounds (fluoranthene, pyrene, and benzo(a)pyrene) were detected at every sample location (including Spring Lake, A10). The highest mean total BNA concentrations were found in area A11 (72 mg/kg), followed by area A10 (36 mg/kg), area A13 (27 mg/kg), area A12 (11 mg/kg), and area A14 (0.25 mg/kg). The maximum detected concentration of all BNA compounds except bis(2-ethylhexyl)phthalate was detected in sample A11-2. This sample contained each BNA compound, except bis(2-ethylhexyl)phthalate, at concentrations between 0.97 mg/kg and 16 mg/kg. In general, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and benzo(g,h,i)perylene were detected in the greatest frequency and at the highest concentrations.

3.4.1.3 Metals

Twenty-one metals were detected in the sediment samples (Table 32). All metals, except mercury (80 percent), cadmium (70 percent), beryllium (50 percent), silver (40 percent), and selenium (10 percent) were detected in all the samples. The highest concentrations of aluminum (18,000 mg/kg), arsenic (23 mg/kg), barium (320 mg/kg), beryllium (1.4 mg/kg), cadmium (3.4 mg/kg), cobalt (30 mg/kg), copper (120 mg/kg), manganese (650 mg/kg), nickel (46 mg/kg), selenium (0.67 mg/kg), silver (1.7 mg/kg), and zinc (600 mg/kg) were detected in sample A13-1. The highest concentrations of iron (25,000 mg/kg), magnesium (6900 mg/kg), mercury (0.54 mg/kg), potassium (1500 mg/kg), and sodium (480 mg/kg) were detected in sample A11-2. The highest concentrations of calcium (5300 mg/kg), chromium (41 mg/kg) and lead (290 mg/kg) were detected in sample A10-2.

3.4.1.4 Pesticide/PCBs

No pesticides and only Aroclor 1254 was detected in the sediment samples collected during Phase III (Table 33). Aroclor 1254 was detected in both samples from locations A12 and A13, one sample from location A11 and neither sample from locations A10 or A14. Location A13 contained the highest mean Aroclor 1254 concentration (5.8 mg/kg), followed by locations A11 (0.60 mg/kg) and A12 (0.14 mg/kg). No PCBs were detected at either location A10 or A14. Sample A13-1 contained the overall highest Aroclor 1254 concentration (11 mg/kg).

3.4.1.5 Grain Size

The grain size results including gravel, sand, silt, and clay fractions and soil families are summarized in Table 34. Grain sizes were highly variable between sample locations although in general samples were composed primarily of sand, with the exception of A14-1, which was composed primarily of clay.

3.4.1.6 TOC

The TOC content of the sediments was highly variable and ranged from 0.32 percent in sample A14-2 to 15 percent in sample A10-2 (Table 35).

3.4.2 Results of Chemical Analysis of Fillet Samples

3.4.2.1 Metals

The results for TAL metal concentrations in edible fish tissue are summarized in Table 36. The following evaluation of the results incorporate the data from Phase II and Phase III.

Calcium, iron, magnesium, potassium, sodium, and zinc were detected in every sample and for every species. Aluminum, chromium, copper, manganese, mercury, and selenium were detected in a majority of the samples (between 65 percent and 100 percent frequency of detection for each species). Cadmium, cobalt, lead, nickel, silver, and vanadium were infrequently detected in the fillet samples (between 0 percent and 35 percent frequency of detection for each species). The frequency of detection for barium was inconsistent between species; it was detected in less than 30 percent of the carp, bullheads, and bass but more than 75 percent of the sunfish and the white sucker.

The highest concentrations of silver (0.4 mg/kg) and vanadium (0.5 mg/kg) were detected in bullheads; the highest concentrations of arsenic (0.2 mg/kg), barium (2.2 mg/kg), iron (25 mg/kg), nickel (1.8 mg/kg), selenium (0.86 mg/kg), and zinc (25 m/kg) were detected in carp. The highest concentrations of cadmium (0.2 mg/kg) and mercury (0.4 mg/kg) were detected in bass. The highest concentration of calcium (6,800 mg/kg), lead (0.2 mg/kg), magnesium (310 mg/kg), and sodium (650 mg/kg) were detected in sunfish. The highest concentrations of aluminum (250 mg/kg), manganese (4.1 mg/kg), and potassium (4,000 mg/kg) were detected in white sucker.

3.4.2.2 Pesticide/PCBs

In the Phase III data set, Aroclors 1248 and 1254 were detected in all fillet samples in all species (Table 37). Generally, Aroclor 1254 was detected at higher concentrations than Aroclor 1248. Aroclor 1254 concentrations ranged up to 42 mg/kg in carp, 2.9 mg/kg in bass, 2.3 mg/kg in white sucker, 1.8 mg/kg in bullheads, and 0.84 mg/kg in sunfish. Aroclor 1248 ranged up to 7.7 mg/kg in carp, 2.4 mg/kg in white sucker, 0.4 mg/kg in bass, 0.3 in bullheads, and 0.1 mg/kg in sunfish.

Seven pesticides were also detected in the fillet samples during Phase III (Table 37). These compounds were detected less frequently and in lower concentrations than the PCBs. Of the pesticide compounds detected in the fillet samples, 4,4'-DDE was detected most frequently (87 percent of the samples) at a maximum concentration of 0.15 mg/kg. The remaining pesticide compounds were detected less frequently [a-chlordane (32 percent), g-chlordane (19 percent), 4,4'-DDD (17 percent), heptachlor epoxide (11 percent), and dieldrin and endrin (2.0 percent)]. The maximum concentration of a-chlordane was 0.25 mg/kg, of g-chlordane was 0.16 mg/kg, of 4,4'-DDE was 0.15 mg/kg, of 4,4'-DDD was 0.1 mg/kg, of dieldrin was 0.06 mg/kg, of heptachlor epoxide was 0.05 mg/kg, and of endrin was 0.04 mg/kg.

Figures 5 through 13 compare PCB and pesticide concentrations in edible fish for each species and at all Phase II and Phase III sample locations. Relative to species, PCBs and pesticides tended to be in the highest concentrations in carp, followed by white sucker, sunfish, bass, and bullhead. Relative to location, there were no overall trends in the edible fish tissue and in some instances the highest concentrations of a contaminant were detected in different locations for different species (e.g., the highest levels of Aroclor 1254 was found at location A13 for carp, A2 for sunfish, A11 for bass, A3 for white sucker, and A5 for bullheads). The highest location mean Aroclor 1248 concentrations (7.2 mg/kg) were detected in carp collected from location A6. The highest location mean Aroclor 1254 concentrations (28 mg/kg) were detected in carp collected from location A13. The highest location mean heptachlor epoxide concentrations (0.72 mg/kg) were detected in carp collected from location A6. The highest location mean g-chlordane concentrations (0.18 mg/kg) were detected in carp collected from location A1. The highest location mean a-chlordane concentrations (0.14 mg/kg) were detected in carp collected from location A10. The highest location mean 4,4'-DDE concentrations (0.14 mg/kg) were detected in carp collected from location A1. The highest location mean 4,4'-DDD concentrations (0.16 mg/kg) were detected in carp collected from location A1. The highest location mean endrin aldehyde concentrations (0.11 mg/kg) were detected in carp collected from location A5. The highest location mean dieldrin concentrations (0.023 mg/kg) were detected in carp collected from location A10. See Section 4.2.2 for additional discussion regarding trends of PCBs and pesticides in edible fish tissue.

4.0 NATURE AND EXTENT OF CONTAMINATION WITHIN THE BOUND BROOK

4.1 Introduction

This section of the report examines the nature and extent of all contaminants found in sediment and fish along the course of the Bound Brook. The objectives of evaluating these data sets are to (1) uncover any trends in contamination along the course of the Bound Brook in relation to the site and downstream of New Market Pond, (2) to make comparisons between contaminant concentrations along the Bound Brook to those in the reference area(s), and (3) to evaluate the relationships between contaminant concentrations in sediment and fish on a location-specific basis.

4.2 Nature and Extent of PCB Contamination in Sediment and Fish

4.2.1 PCBs in Sediment

Aroclor 1254 was the only PCB mixture detected in sediment. Mean concentrations (dry weight basis) were highest at location A2 (14 mg/kg; downstream of the site) and lowest (not detected) at locations A7 (downstream end of New Market Pond), A9 (upstream reference), A10 (Spring Lake), and A14 (furthest downstream location). Mean Aroclor 1254 concentrations were relatively high at locations A1 (2.2 mg/kg; adjacent to the site), A13 (5.9 mg/kg; downstream of New Market Pond), A5 (2.8 mg/kg), and A6 (3.4 mg/kg; within New Market Pond). Since the lowest concentrations detected along the Bound Brook were non-detects, these levels are comparable to those from the reference areas A9 and A10 (also non-detects).

There does not appear to be a clear PCB gradient in sediment of the Bound Brook. It becomes apparent, however, that PCBs are ubiquitous in sediments of the Bound Brook with relatively high concentrations present downstream of the site. In addition, there was high variability between PCB concentrations in sediment samples collected at the same location. PCB concentrations ranged from below the detection limit to 4.5 mg/kg (dry weight basis) in the six samples collected at location A1 and ranged from 0.55 to 5.1 mg/kg (dry weight basis) in the two samples collected at location A5.

4.2.2 PCBs in Fish

Aroclor 1248 and Aroclor 1254 were detected in all fillet samples tested; only Aroclor 1254 was detected in the sediment and whole body forage fish samples. Generally, Aroclor 1254 was detected at higher concentrations than Aroclor 1248. Variability in the number, species, size, and age of fish collected at each location would mask any trends that may exist. The purpose of the edible fish tissue collection was to collect data for human health risk assessment and was therefore not well suited to perform location by location comparisons or evaluate contaminant gradients. The data were collected using methods that were suited for human health risk assessment and not evaluations of contaminant
gradients (e.g., largest fish were used as opposed to a common size range between areas and large number of species with few replicates were used as opposed to few species with a larger number of replicates).

For location by location comparisons, an attempt was made to normalize the data by fish size and lipid content but neither of these methods seemed to be valid since there were no correlations between contaminant levels and fish size and/or lipid content. The results (based on mean concentration for each species collected from each location) indicate that the highest PCB concentrations are located in the length of the Bound Brook that extends from the reference area downstream to New Market Pond. Here, the mean total PCB concentrations in white sucker fillets for each location ranged from 3.9 to 9.5 mg/kg, wet weight. White suckers were also collected from Spring Lake and downstream of New Market Pond to the Raritan River. The mean total PCB concentrations in white sucker fillets for each location in this length of the Bound Brook were lower and ranged from 0.4 to 2.0 mg/kg. This same trend is also noted with the mean total PCB results for the pumpkinseed. Fillets of pumpkinseeds collected from the stretch of the Bound Brook located from location A1 downstream to New Market Pond ranged from 1.9 to 5.5 mg/kg, wet weight. The mean concentration of total PCBs in pumpkinseed fillet downstream of New Market Pond to the Raritan River ranged from 0.17 to 0.86 mg/kg, wet weight. The PCB results for largemouth bass and bullhead are not clear due to the low number of samples collected from each of the locations.

The results for the PCBs in carp fillet do not follow the same trend as those found in the pumpkinseed and white sucker. The lowest concentrations of PCBs were noted in the carp collected from the Reference Area (A9) and from Spring Lake (A10). Both of these locations are up gradient of the site. However, the fish from the reference area were much smaller than those collected downstream. The highest mean concentrations of total PCBs in carp fillet were detected in the fish collected from the two locations within New Market Pond, A5 and A6 (22 to 24 mg/kg, wet weight, respectively) and from two of the downstream locations, A12 and A13 (27 and 31 mg/kg, wet weight, respectively). The PCB results for the carp collected from A13 are the highest of any fish collected during this study.

A1 - adj. to site
A2 - below Veteran's Park
A9 - upstream ref.
A10 - Spring Lake ref.
A4 - New Brunswick Ave bridge
A6 - West New Market Pond
A14 - Lincoln Blvd. bridge

When the PCB residue results are examined across all species combined (i.e., one broad category of "edible fish tissue" instead of on a per species basis), the results for Aroclor 1248, Aroclor 1254, and total PCBs exhibit a trend similar to each other. Aroclor 1248, Aroclor 1254, and total PCBs increase from the locations up gradient of the site (A9 and A10) to location A1, and again from location A1 to location A2, then decrease toward location A4. The levels then increase toward location A6 and decrease progressively toward location A14.

The presence of Aroclors 1248 and 1254 in fish tissue collected up gradient of the site is potentially due to PCB contamination that is not site-related and/or fish migration up and downstream of the site. In Spring Lake, however, the presence of Aroclors 1248 and 1254 in the fish and their absence in sediments suggest that there may be a different source of PCBs leading into this lake, such as the Cedar Brook. The possibility that the fish collected from Spring Lake had spent a portion of their life span in the Bound Brook down gradient from the site is unlikely due to a high retaining wall (spillway) at the downstream end of Spring Lake, making it unlikely that fish would be able to migrate from downstream locations into Spring Lake except under extremely high flow conditions. Since PCBs were detected in every fish sample collected from Spring Lake, it remains unlikely that the PCBs in the tissues of these fish are the result of exposure to PCBs in the Bound Brook downstream of the Cornell-Dubilier Electronics site.

4.3 Nature and Extent of Pesticides Contamination in Sediment and Fish

4.3.1 Pesticides in Sediment

Due to the small number of detections of pesticides in sediment, pesticides were not examined for trends in their nature and extent in sediment along the Bound Brook.

4.3.2 Pesticides in Fish

Nine pesticides (heptachlor epoxide, g-chlordane, a-chlordane, p, p'-DDE, p, p'-DDD, endrin, endrin aldehyde, dieldrin, and methoxychlor) were detected in the edible fish samples. Methoxychlor was mostly likely a laboratory contaminant since it was detected in the laboratory blanks and only in one sample at a concentration near the detection limit.
The compound 4,4'-DDE was the most frequently detected pesticide found in the fish fillets. Approximately 85 percent of the fish captured contained detectable levels of this pesticide. However, there are no distinct trends among species with the exception that carp contained the highest concentrations compared to the other species collected. When the mean concentrations of 4,4'-DDE were calculated for each location across all species, trends among the locations were observed. The mean 4,4'-DDE concentration in edible fish tissue was low at the two locations up gradient of the site (A9 and A10), increased toward locations A1 and A2, and drastically decreased toward location A5. The mean 4,4'-DDE tissue concentration then increased again at location A6 (the upstream New Market Pond location) and gradually decreased from there toward location A14. Heptachlor epoxide was detected most frequently in the samples collected from the reference area downstream to New Market Pond (85 percent). The frequency of detection of this pesticide drops below New Market Pond, and heptachlor epoxide is only detected in one pumpkinseed collected at location A12. This pesticide was detected in five of the eleven fish collected from Spring Lake.

Chlordane was detected in samples collected both upstream and downstream of New Market Pond. However, this pesticide was only detected in white sucker, carp, and catfish. It was not detected in any pumpkinseed or largemouth bass. It should be noted that technical grade chlordane was detected in the three carp and the three white suckers collected from Spring Lake. Technical grade chlordane is defined as the presence of both a-chlordane and g-chlordane. It should also be noted that dieldrin was only detected in four fish and these fish were also captured in Spring Lake.

Endrin aldehyde was only detected in largemouth bass, carp, white sucker, and pumpkinseed collected from New Market Pond. Endrin was only detected in one carp collected from the Bound Brook (A12) downstream of New Market Pond.

The presence of dieldrin in the fish and sediment collected from Spring Lake, and the presence of chlordane in the fish but not in the sediment collected from Spring Lake, suggests that there may be a source for these contaminants leading into Spring Lake, such as the Cedar Brook.

4.4 Nature and Extent of VOC Contamination in Sediment and Fish

4.4.1 VOCs in Sediment

Due to the small number of VOC detections in sediment, these compounds were not examined for trends in nature and extent along the Bound Brook.

4.4.2 VOCs in Fish

Volatile organic compounds were not evaluated in fish tissue. It was assumed that any VOCs accumulated into living fish tissue are rapidly metabolized.

4.5 Nature and Extent of BNA Compounds Contamination in Sediment

4.5.1 Low/High Molecular Weight PAHs

Low molecular weight PAHs were highest at location A5 (upstream end of New Market Pond) and lowest at location A14 (furthest downstream location); high molecular weight PAHs were highest at location A11 (downstream end of New Market Pond) and lowest at location A14 (furthest downstream location). With the exception of location A5, the low molecular weight compounds remain low in the Bound Brook upstream of New Market Pond, although the high molecular weight PAHs show an incremental increase from locations A1 to A3 (adjacent to and downstream of the site). Both low and high molecular weight PAHs are high in the upstream end of New Market Pond, low near the downstream end of New Market Pond, and fluctuate downstream of New Market Pond, until reaching the lowest concentrations at location A14.

For both low and high molecular weight PAHs, the concentrations detected at reference locations A9 (Bound Brook up gradient of the site) and A10 (Spring Lake) are higher than several of the concentrations detected in the Bound Brook down gradient of the site. The presence of low and high molecular weight PAHs in the sediment collected from Spring Lake suggests that there may be a source for these contaminants leading into Spring Lake, such as the Cedar Brook. In addition, the presence of relatively high concentrations of both low and high molecular weight PAHs up gradient of the site compared to some locations down gradient of the site suggests that PAH contamination is not limited to those areas down gradient of the site.

4.5.2 Remaining BNA Compounds

The BNA compounds that do not fall into the category of low or high molecular weight PAHs were grouped together as "remaining BNA compounds." Similar to the high molecular weight PAHs, the remaining BNA compounds were highest at location A1 (adjacent to the site) and lowest at location A14 (furthest downstream location). However, unlike the PAH compounds, the remaining BNA compounds show high concentrations around the site area, immediately upstream of New Market Pond, and the upstream end of New Market Pond. These concentrations progressively decrease downstream of New Market Pond to "non-detect" at location A14.

Similar to the low and high molecular weight PAHs, the concentrations of the remaining BNA compounds detected at reference locations A9 (Bound Brook) and A10 (Spring Lake) are higher than several of the concentrations detected in the Bound Brook down gradient of the site. The presence of other BNA compounds in the sediment collected from Spring Lake suggests that there may be a source for these contaminants leading into Spring Lake, such as the Cedar Brook. In addition, the presence of relatively high concentrations of other BNA compounds up gradient of the site suggests that this contamination is not limited to those areas down gradient of the site.

4.5.3 Total BNAs

When the BNA compounds are totaled and examined as one class of compounds, the characteristics of both the PAH compounds and the remaining BNA compounds are evident. Total BNAs are highest at location A5 (upstream end of New Market Pond) and are lowest at location A14 (furthest downstream location). The concentrations of total BNAs are high around the site area, at the upstream end of New Market Pond, and immediately downstream of the New Market Pond. With the exception of location A14, the lower concentrations in the Bound Brook are comparable to those of locations A9 (Bound Brook reference) and A10 (Spring Lake). Total BNAs were lower at location A9 than at location A10.

4.6 Nature and Extent of Metals Contamination in Sediment and Fish

4.6.1 Metals in Sediment

All of the metals, with some variation, exhibit the following general trend. Concentrations tend to be high adjacent to (location A1) and downstream of the site (usually more so at location A3 than location A2). Concentrations decrease to relatively low levels upstream of New Market Pond (location A4) and at the upstream end of New Market Pond (location A5), but then increase sharply toward the downstream end of New Market Pond (locations A6). Progressing downstream of New Market Pond, metals concentrations are generally lower at location A7, then they increase slightly at location A11, decrease at A12, increase sharply at A13, and finally attenuate by location A14 (furthest downstream location). Metals levels at location A9 (the upstream reference) tend to be greater than the metal levels detected at locations A4 and A5 (downstream of the site). Metal levels at location A10 (Spring Lake) tend to be lower than those detected at location A9 (Bound Brook reference).

Mean total organic carbon follows a similar trend to that of the metals. Mean TOC concentrations are high adjacent to the site (16 percent at location A1) and progressively decrease towards location A5 (4.82 percent). Like the metal concentrations, mean total organic carbon levels increase sharply at location A6 (20.8 percent) and progressively decrease toward location A14 (1.96 percent).

4.6.2 Metals in Fish

Although the results for metals in edible fish tissue were variable, when all of the fish species are grouped together into one category (as "edible fish tissue"), some general trends appear. The first trend exhibits a general decrease in metal concentrations from location A1 to A14. However, two peaks appear along this gradient, one around location A6 and the other around location A13. The following metals fall into this category: iron, selenium, and zinc.

Another trend also exhibits two peaks; however, these are around locations A4 and A13. The overall end result at location A14 is that metal concentrations are not much different or are greater than those of location A1. The following metals fall into this category: barium, calcium, magnesium, potassium, and sodium.

Aluminum and arsenic exhibit three peaks (around locations A1, A6, and A13) and ends at location A14 with a concentration lower than that of location A1. Three metals, chromium, mercury, and nickel, show an increase in concentration from location A1 to location A14, although the levels are highly variable. Copper and manganese do not appear to exhibit any trend along the course of the Bound Brook.

4.7 Conclusions

Based on this evaluation, the following conclusions about the contamination of sediment and edible fish tissue along the Bound Brook are apparent:

- Many contaminants are present at relatively high levels adjacent to and/or immediately down gradient of the site. These concentrations progressively decrease toward location A14, near the confluence of the Green Brook and the Raritan River, with the exception of a sharp increase either immediately upstream of New Market Pond or within New Market Pond. The increase in concentrations of many contaminants immediately upstream or within New Market Pond may be the result of a slower rate of flow, resulting in greater deposition of particles onto which the contaminants are adsorbed. Regardless, the high concentrations adjacent to and directly downstream of the Cornell-Dubilier Electronics site indicate that the site is the primary source of many of the contaminants of concern within the section of the Bound Brook corridor investigated for this study.

- The presence of contaminants up gradient of the site (at the reference and in Spring Lake) suggest that, in addition to the Cornell-Dubilier Electronics site, other sources of contamination exist within the Bound Brook stream corridor.

5.0 ECOLOGICAL RISK ASSESSMENT OF THE BOUND BROOK AND ITS ASSOCIATED FLOOD PLAIN

5.1 Problem Formulation

The risk assessment for this site was designed to evaluate the potential ecological threats from exposure to site contaminants and to provide data that may be used to establish site-specific ecotoxicologically-based soil and sediment remedial goals. The problem formulation process for this risk assessment includes the identification of contaminants of potential concern (COPCs), the identification of the exposure pathways for the COPCs, a determination of the assessment endpoints for the site, the formulation of testable hypotheses, the development of a conceptual model, the determination of the measurement endpoints for the site, the development of a study design, and an analysis of the uncertainties that may be associated with the risk assessment.

5.1.1 Summary of the Screening-Level Risk Assessment

Based on the results of a previous preliminary risk assessment prepared by Region II U.S. EPA, PCBs, metals (arsenic, cadmium, lead, and zinc), and PAHs were identified as potential contaminants of concern. However, a full contaminant analysis was not available at the time of this preliminary risk assessment. Therefore, a screening-level risk assessment was repeated using new data collected for the current risk assessment. For this screen, the maximum concentrations of contaminants detected in the surface water, sediment, and soil collected from the site for the current risk assessment were compared to various benchmark values.

For the purposes of this risk assessment, water, sediment, and soil samples were collected and analyzed for target analyte list (TAL) metals, volatile organic compounds (VOCs), base-, neutral-, and acid-extractables (BNAs), pesticides, and polychlorinated biphenyls (PCBs). The data from these analyses were screened using a risk characterization process that relates exposure concentrations to concentrations that potentially cause adverse effects. The exposure concentrations were the highest concentrations detected for each contaminant in the surface water, sediment, and soil samples collected from the site (not including the reference samples). The benchmark concentrations used in the screening-level risk assessment were the U.S. EPA Region III Screening Levels (U.S. EPA 1995).

The hazard quotient method was used in the screening-level risk assessment to estimate the potential risk for each contaminant detected. The hazard quotient method compares exposure concentrations to benchmark values and is expressed as a ratio per the following formula:

$$HQ = EC \div BV$$

where:

HQ = Hazard Quotient
EC = Exposure Concentration
BV = Benchmark Value

An elevated hazard quotient (greater than one) resulting from the screening-level risk assessment indicates that exposure to the contaminant should be evaluated further for potential risk. More data are needed to determine if the contaminants exceeding the benchmark values pose a potential risk to ecological receptors at the site. The contaminants for which the maximum concentrations detected in water, sediment, and soil exceeded their benchmark values are highlighted in Table 38. Also highlighted are contaminants that do not have a chemical specific benchmark for one or more matrices.

In summary, two contaminants exceeded their benchmark values in surface water, and five contaminants that were detected in surface water did not have a surface water benchmark. In sediment, thirty contaminants exceeded their benchmark values, and an additional twenty-six contaminants that were detected in sediment had no benchmark. In soil, thirty-six contaminants exceeded their benchmarks, and an additional twenty-four contaminants were detected in soil but did not have a benchmark in soil (Table 38).

5.1.2 Identification of Contaminants of Potential Concern

The results of the screening-level risk assessment were used to identify most of the COPCs for the ecological risk assessment. Any contaminant that either exceeded its benchmark value for soil, sediment, or water, or that was detected in a matrix for which a benchmark did not exist, was identified as a contaminant of concern. The screening-level risk assessment assumed that receptors were exposed to the highest concentration detected in the considered media and that the contaminant was biologically available and completely assimilated. On the basis of concentration and toxicity, the screening-level risk assessment identified a total of seventy-nine contaminants of concern. Of these, eighteen were VOCs, thirty-four were BNAs, twenty-three were metals, three were pesticides, and one was a PCB.

In addition to the contaminants that were identified in the screening level risk assessment, six additional pesticide-related compounds and an additional PCB were detected in fish fillet samples. These compounds were a-chlordane, g-chlordane, heptachlor epoxide, 4,4'-DDE, endrin aldehyde, methoxychlor, and Aroclor 1248. Due to the propensity of pesticides and PCBs to bioaccumulate and biomagnify in the food chain, these compounds were also identified as contaminants of potential ecological concern for this risk assessment. General information on the sources, hazards, and fate of the contaminants of potential concern evaluated in this risk assessment can be found in Appendix E, and a complete list of these COPCs is compiled on the following page.

Of the contaminants of concern identified in the table, the pesticides and PCBs, as well as arsenic, cadmium, lead, mercury, and selenium were evaluated for their potential risk using three methods: 1) a food chain model; 2) a comparison between contaminant body burdens and literature-based values associated with toxic effects; and 3) the use of a sediment toxicity test.

The remaining contaminants of concern listed in the table are considered to be direct-acting acute toxicants and are not known to significantly bioaccumulate and/or were demonstrated not to be bioaccumulative based on the analytical data obtained from the samples collected in the field. Therefore, they were not evaluated using the food chain model nor by comparing measured body burdens to literature-based values.

Of these non-bioaccumulative direct-acting contaminants of concern, those that were detected in sediment and either exceeded their sediment benchmark or did not have a sediment benchmark were evaluated using the results of a sediment toxicity test. Some of

BNAs	Volatile Organic Compounds
2-methylnapthalene	cis-1,2-dichloroethene
Acenapthene	trans-1,2-dichloroethene

Acenapthylene	1,1,2,2-tetrachloroethane
Anthracene	1,2,3-Trichlorobenzene
Fluorene	1,1,1-Trichloroethane
Napthalene	Trichloroethene
Phenanthrene	Trichlorofluoromethane
Benzo(a)anthracene	2-Hexanone
Benzo(a)pyrene	Acetone
Benzo(b)fluoranthene	n-Butylbenzene
Benzo(g,h,i)perylene	Carbon Disulfide
Benzo(k)fluoranthene	Chloroethane
Chrysene	Chloromethane
Dibenz(a,h)anthracene	p-Isopropyltoluene
Fluoranthene	Methylene Chloride
Indeno(1,2,3-c,d)pyrene	Methyl tertial butyl ether
Pyrene	Toluene
Acetophenone	Trichloroethene
Benzidine	**Metals**
Benzoic acid	Aluminum
1,2,4-Trichlorobenzene	Antimony
bis(2-chloroisopropyl)ether	Arsenic
2,6-Dinitrotoluene	Barium
3,3'-Dichlorobenzidine	Beryllium
4-Methylphenol	Cadmium
4-Nitroaniline	Calcium
bis(2-Ethylhexyl)phthalate	Chromium
Butylbenzylphthalate	Cobalt
Dibenzofuran	Copper
Diethylphthalate	Iron
Dimethylphthalate	Lead
Di-n-butylphthalate	Magnesium
Di-n-octylphthalate	Manganese
Hexachlorobenzene	Mercury
Pesticides	Nickel
Dieldrin	Potassium
Methoxychlor	Selenium
4,4'-DDD	Silver
4,4'-DDE	Sodium
Endrin aldehyde	Thallium
Heptachlor	Vanadium
Heptachlor epoxide	Zinc
a-Chlordane	**PCBs**
g-Chlordane	Aroclor-1254
	Aroclor-1248

these contaminants were also detected in surface water and/or soil and either exceeded their benchmarks or did not have a benchmark for the surface water or soil matrix in which they were detected. The potential risk posed by these contaminants in soil and surface water was not evaluated in this risk assessment because surface water and soil toxicity tests were not performed.

The remaining non-bioaccumulative direct-acting contaminants of concern were either not detected in sediment or were detected in sediment but did not exceed their sediment benchmark, but were detected in surface water or soil and either exceeded their benchmarks in these matrices or did not have appropriate benchmarks for the surface water and/or soil matrix in which they were detected. The potential risk of these contaminants in soil and surface water could also not be evaluated in this risk assessment because surface water and soil toxicity tests were not performed.

5.1.3 Exposure Characterization

The objective of the exposure characterization is to determine the media and the pathways through which assessment endpoints may be affected by site contaminants. Potential exposure pathways are dependent on the extent and magnitude of contamination, the site habitat, the receptor species present at the site, and the environmental fate and transport of the COPCs.

The Cornell-Dubilier Electronics site occupies approximately 25 acres in an industrial/commercial/residential area, and it is bordered by commercial businesses and residences along its southwest and northwest border. The eastern portion of the site is bordered from the southeast to the northeast by wetlands and the Bound Brook, which traverses the site property at the very southeast corner of the site. The Bound Brook flows northwest and joins with the Cedar Brook (which drains Spring Lake to the northeast) approximately 0.75 miles downstream of the site. The Bound Brook then flows for 1.5 miles before emptying into New Market Pond. There are approximately 34 acres of wetlands within 0.5 miles of the site. Wetlands that border the site to the southeast diminish significantly as the creek heads downstream towards the northwest (U.S. EPA 1997b). In addition to these wetlands, additional wetlands and flood plains are found adjacent to the Bound Brook as it flows downstream. The types of wetlands present adjacent to and downstream of the site include open water, nontidal emergent, deciduous scrub-shrub, and deciduous forested wetlands.

A variety of organisms are expected to inhabit the Bound Brook and its surrounding areas. Emergent insects are expected to inhabit the bottom of the Bound Brook during their larval and pupal stages, and other benthic invertebrates will inhabit the Bound Brook throughout their life cycle. Amphibians also expected to use the Bound Brook for reproduction and habitat. Fish are known inhabit the stream and feed on plants, invertebrates, and other fish. A variety of mammals and birds are expected to use the banks of the Bound Brook for building nests and to consume the fish, invertebrates, and amphibians that inhabit the Bound Brook. Amphibians, mammals, and birds are also expected to utilize the flood plains of the Bound Brook and its associated wetlands for habitat, reproduction, and food as well.

A site visit was conducted by the EPA in April, 1996, in which wildlife sightings were noted. Birds sighted adjacent to and downstream of the site included Canada goose, American robin, killdeer, great blue heron, domestic geese, downy woodpecker, red-tailed hawk, common flicker, northern cardinal, red-winged blackbird, mourning dove, common grackle, blue jay, European starling, white-throated sparrow, song sparrow, crow (sp.), rock dove, swallow (sp.), and northern mockingbird. Mammal and herptile sightings included eastern cottontail, eastern gray squirrel, raccoon (prints), possibly woodchuck (based on many large apparently active burrow openings), eastern painted box turtle, and frog(s) (U.S. EPA 1996).

As a result of past disposal practices, elevated levels of PCBs, lead, and cadmium had been found to be present in the soil at the site. The sediment of the Bound Brook adjacent to the site had also been found to be contaminated with cadmium, copper, lead, polyaromatic hydrocarbon (PAHs), and PCBs. The potential exists for the contamination to migrate further downstream in the Bound Brook and into its associated flood plains, as well as into New Market Pond.

Ecological receptors are potentially exposed to contaminants in abiotic matrices through direct contact, intentional ingestion (e.g., consumption of water and food items), and incidental ingestion (e.g., soil or sediment particles adhered to or entrained in food items). Transfer of the contaminants to receptors could also occur through processes of bioaccumulation and bioconcentration, whereby upper trophic level receptors are exposed to site contaminants through the ingestion of contaminated food items. Therefore, ecological receptors inhabiting the Bound Brook, New Market Pond, and the associated flood plains and surrounding areas are potentially at risk from the contamination originating from the Cornell-Dubilier Electronics site.

Chemical analyses of surface water, sediment, soil, and biota collected in the Bound Brook, New Market Pond, and the associated flood plains were used to determine the levels of contaminants in these areas. These measured contaminant concentrations were used in the risk assessment to represent the conditions of site-specific exposure.

5.1.4 Selection of Assessment Endpoints

Assessment endpoints are explicit expressions of the actual environmental values (e.g., ecological resources) that are to be protected. Valuable ecological resources include those without which ecosystem function would be significantly impaired or those providing critical resources (e.g., habitat). Appropriate selection and definition of assessment endpoints are critical to the utility of a risk assessment as they focus risk assessment design and analysis. It is not practical or possible to directly evaluate potential risks to all of the individual components of the ecosystem at the site, so assessment endpoints are used to focus the risk assessment on particular components of the ecosystem that could be adversely affected by the contaminants released from the site. In general, the assessment endpoints selected for the site are aimed at the viability of terrestrial and aquatic populations and organism survivability.

A review of the habitat of the Bound Brook and its associated stream corridor adjacent to and downstream of the Cornell-Dubilier Electronics site provided information for the selection of assessment endpoints. A variety of invertebrates, vertebrates, and plants inhabit the area. In addition, many birds and mammals inhabiting this and adjacent areas could prey on the flora and fauna inhabiting the study area. Therefore, the assessment endpoints focused on these biological groups.

Ten assessment endpoints were developed as part of the investigation work plan (U.S. EPA 1997d) to evaluate the potential risk of contaminants in the Bound Brook and its associated stream corridor adjacent to and downstream of the Cornell-Dubilier Electronics site. By evaluating and protecting these assessment endpoints, the stream ecosystem as a whole should also be protected. The specific assessment endpoints that were evaluated in this risk assessment are listed next.

5.1.4.1 Assessment Endpoint #1: Protection of the structure and function of the stream

The health of the stream has a direct impact on the health of the entire ecosystem; impacts to the stream relate directly to degradation of the whole ecosystem. The maintenance of structure and function of the stream is important to the ecosystem since the stream provides exclusive habitat for many species of plants and animals. Streams also process energy, organic matter, and nutrients. Biota utilizing the stream corridor often rely extensively on the resources (i.e., forage) provided by the stream to support survival, growth, and reproduction.

5.1.4.2 Assessment Endpoint #2: Protection of the structure and function of the stream corridor (inclusive of associated flood plains and wetlands)

The health of the stream corridor has a direct impact on the health of the entire ecosystem; impacts to the stream corridor relate directly to degradation of the whole ecosystem. The maintenance of structure and function of the stream corridor is important to the ecosystem since it provides a significant portion of the energy, organic matter, and nutrient inputs to the stream. Stream corridors usually provide high quality edge habitat for a variety of relatively sedentary birds, reptiles, amphibians and mammals, which in turn rely on the stream to forage. The sedentary species that generally congregate near streams due to habitat and food availability are often preyed upon by more far-ranging species that utilize the stream corridor.

5.1.4.3 Assessment Endpoint #3: Protection of fish recruitment in the stream

Fish function in nutrient and energy transfer within the stream and as forage items for animals that inhabit the stream and the stream corridor. Several predators rely solely or primarily on fish as forage. Fish typically provide a large proportion of the biomass utilizing the stream and are in a wide range of trophic positions (e.g., predatory, bottom feeders) in stream communities. Due to these factors, impairment to fish communities would have strong impacts on nutrient and energy cycling in the stream and overall ecosystem health.

5.1.4.4 Assessment Endpoint #4: Protection of benthic invertebrate communities

Invertebrate communities constitute a vast portion of the base of the food chain for the entire ecosystem. Impacts to invertebrate communities would have significant direct and indirect effects (e.g., loss or reduction of forage or transfer of bioaccumulative compounds) on higher trophic organisms (e.g., fish, birds, herpetiforms). Invertebrates process organic material in the stream and are thus important in nutrient and energy transfer and stream ecosystem functions.

5.1.4.5 Assessment Endpoint #5: Protection of amphibian populations, specifically through the protection of embryonic and larval stages

Embryo and larval stages are critical life history periods for amphibians and other species that share similar life-histories. Examination of the effect of contaminants on amphibians during these stages provides a direct measure of reproductive success and a measure of recruitment success into the adult population. Amphibians represent a significant source of forage to higher trophic-level organisms (including birds, fish, and mammals). Amphibians are also considered to be sensitive to a wide range of contaminants and are considered to be a sensitive indicator species for adverse effects to the ecosystem.

5.1.4.6 Assessment Endpoint #6: Protection of insectivorous birds

Insectivorous birds are important in the population regulation of potentially harmful aquatic insects, such as mosquitoes. Impacts to insectivorous birds would allow species of potentially harmful aquatic insects to obtain higher population levels than would typically occur in a system that was not impacted. Insectivores are important in nutrient processing and energy transfer between the aquatic and terrestrial environment.

5.1.4.7 Assessment Endpoint #7: Protection of omnivorous birds

Omnivorous birds were selected for evaluation because of their diverse methods of foraging (i.e., dabbling). Of the bird species utilizing the system, omnivorous birds have been reported to have the greatest soil/sediment ingestion rates. Soil/sediment ingestion typically accounts for a vast majority of the contaminant uptake in food chain accumulation models. Omnivorous birds also help to regulate the growth of aquatic vegetation, algae, and benthic invertebrates. Omnivorous birds are an important pathway by which nutrient and energy in the stream may be transferred between the aquatic and terrestrial environment.

5.1.4.8 Assessment Endpoint #8: Protection of piscivorus birds

Piscivorus birds are an upper trophic-level organism that rely primarily on fish as forage. Piscivorus birds selectively forage on stream fish, regulating populations. Foraging behavior of piscivorus birds represents another pathway by which energy is transferred between aquatic and terrestrial ecosystems. Predators also are often required to keep prey in check, and impacts to predators could cause detrimental population explosions in prey species.

5.1.4.9 Assessment Endpoint #9: Protection of omnivorous mammals

Omnivorous mammals help to regulate benthic invertebrate and fish populations. Omnivorous mammals are an important pathway by which nutrient and energy are transferred between the terrestrial and aquatic environment. In many urban and/or suburban ecosystems, these species typically represent the highest trophic levels and therefore, for contaminants that biomagnify, would be receiving the greatest doses of contaminants from their forage.

5.1.4.10 Assessment Endpoint #10: Protection of carnivorous mammals

Carnivorous mammals are upper trophic-level organisms that selectively forage on lower trophic-level organisms such as small mammals. Foraging behavior of carnivorous mammals represents a pathway by which energy is transferred to higher trophic levels within the terrestrial ecosystem. Predators also are often required to keep prey in check, and impacts to predators could cause detrimental population explosions in prey species.

5.1.5 Production of Testable Hypotheses

The testable hypotheses are specific risk questions that are based upon the assessment endpoints. For the purposes of this risk assessment, the testable hypotheses follow.

5.1.5.1 Assessment Endpoint #1: Protection of the structure and function of the stream

Are levels of site contaminants sufficient to cause adverse alterations to the structure and function of stream communities?

5.1.5.2 Assessment Endpoint #2: Protection of the structure and function of the stream corridor (inclusive of associated flood plains and wetlands)

Are levels of site contaminants sufficient to cause adverse alterations to the structure and function of stream corridor communities?

5.1.5.3 Assessment Endpoint #3: Protection of fish communities

Are levels of site contaminants sufficient to cause adverse alterations to the structure and function of fish communities in the Bound Brook?

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment of fish that inhabit the Bound Brook ?

5.1.5.4 Assessment Endpoint #4: Protection of benthic invertebrate communities

Are levels of site contaminants in surface water and sediment sufficient to cause adverse alterations to the structure and function of the aquatic invertebrate communities?

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to aquatic invertebrates that inhabit the Bound Brook?

5.1.5.5 Assessment Endpoint #5: Protection of amphibian populations, specifically through the protection of embryonic and larval stages

Are levels of site contaminants sufficient to cause adverse alterations to the development, growth or reproductive capacity of the amphibian community?

5.1.5.6 Assessment Endpoint #6: Protection of insectivorous birds

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to insectivorous birds that utilize the Bound Brook stream corridor?

5.1.5.7 Assessment Endpoint #7: Protection of omnivorous birds

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to omnivorous birds that utilize the Bound Brook and its associated stream corridor?

5.1.5.8 Assessment Endpoint #8: Protection of piscivorus birds

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to piscivorus birds that utilize the Bound Brook and/or its associated stream corridor?

5.1.5.9 Assessment Endpoint #9: Protection of omnivorous mammals

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to omnivorous mammals that utilize the Bound Brook stream corridor?

5.1.5.10 Assessment Endpoint #10: Protection of carnivorous mammals

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to carnivorous mammals that utilize the Bound Brook stream corridor?

5.1.6 Conceptual Model

The conceptual model is based on contaminant and habitat characteristics to identify critical exposure pathways to the selected assessment endpoints. At the Cornell-Dubilier Electronics site, contaminants in the water, sediment, and soil may come in contact with the aquatic, benthic, and terrestrial receptors inhabiting the Bound Brook and its associated stream corridor. Benthic invertebrates in the Bound Brook may be exposed to site contaminants through direct contact with and/or ingestion of the sediment and overlying water. Aquatic vertebrates may be exposed to site contaminants via direct contact with water and sediment, ingestion of water, incidental ingestion of sediment adhered to food items, and ingestion of contaminated food. Mammals and birds may be exposed to site contaminants via ingestion of contaminated food, incidental ingestion of sediment or soil, and ingestion of surface water.

Based on this conceptual model, and dependent upon the availability of information, the following pathways will be considered in this risk assessment:

I. Benthic Invertebrate
Direct contact with water
Direct contact with sediment
Ingestion of sediment

II. Wetland Vertebrate
Direct contact with water
Direct contact with sediment
Ingestion of water
Incidental ingestion of sediment
Ingestion of invertebrates

III. Aquatic Vertebrate
Direct contact with water
Direct contact with sediment
Ingestion of water
Incidental ingestion of sediment
Ingestion of invertebrates

IV. Insectivorous Bird
Ingestion of water
Ingestion of invertebrates

V. Omnivorous Bird
Ingestion of water
Incidental ingestion of sediment
Ingestion of invertebrates

VI. Piscivorus Bird
Ingestion of water
Incidental ingestion of sediment
Ingestion of aquatic vertebrates

VII. Omnivorous Mammal
Ingestion of water
Incidental ingestion of sediment
Ingestion of plants
Ingestion of aquatic invertebrates
Ingestion of aquatic vertebrates

VIII. Carnivorous Mammal
Ingestion of water
Incidental ingestion of soil
Ingestion of terrestrial vertebrates

5.1.7 Measurement Endpoints

Each of the testable hypotheses will be evaluated using one or more measurement endpoints. The number of measurement endpoints chosen for each assessment endpoint is determined by the type of habitat, the mechanism(s) of toxicity, and the feasibility of collecting the supporting data. When more than one measurement endpoint was used to evaluate a single assessment endpoint, a weight-of-evidence approach was employed, whereby the measurement endpoints were treated as lines of evidence. The overall risk to each assessment endpoint was then determined based on the results of the evaluation of each line of evidence, having taken into consideration the degree of importance of each line of evidence.

The measurement endpoints were selected to represent the mechanisms of toxicity and exposure pathways for the assessment endpoints and to answer questions posed by the testable hypotheses for each assessment endpoint. Where adverse effects are observed, the measurement endpoints are also used in developing preliminary ecotoxicologically-based remedial goals. For this study, the following measurement endpoints, or lines of evidence, were identified for each of the assessment endpoints evaluated in this risk assessment:

5.1.7.1 Measurement Endpoint for Assessment Endpoint #1: Protection of the structure and function of the stream

The overall functioning of the stream communities in the Bound Brook will be inferred through the evaluation of assessment endpoints 3, 4, 5, 6, 7, 8, and 9. These components provide information regarding the trophic levels and habitats within the Bound Brook and subsequently offer insights into the overall functioning of the habitat.

5.1.7.2 Measurement Endpoint for Assessment Endpoint #2: Protection of the structure and function of the stream corridor (inclusive of associated flood plains and wetlands)

The overall functioning of the Bound Brook stream corridor will be inferred through the evaluation of assessment endpoints 5, 6, 7, 8, 9, and 10. These components provide information regarding the trophic levels and habitats associated with site wetlands and flood plains of the Bound Brook and subsequently offer insights into the overall functioning of the habitat.

5.1.7.3 Measurement Endpoint for Assessment Endpoint #3: Protection of fish communities

Three lines of evidence were used to assess the effects of contamination within the Bound Brook on the fish communities that inhabit it. First, fish at various trophic levels (bottom feeders, forage fish, and predatory fish) were collected from the Bound Brook adjacent to and downstream of the site and analyzed for PCBs, pesticides, and metals. Up to three replicates of fish of each species were filleted and analyzed, and up to eight replicates of forage fish (whole body) were also

analyzed. Data from the results of these tissue analyses were compared with values found in the literature to be associated with toxic effects or reproductive impairment of fish.

The second line of evidence to determine whether fish communities within the Bound Brook downstream of the site are potentially at risk was a determination of the magnitude and number of lesions in the fish. During processing of the fish samples, gross observations of any lesions were made and recorded. The magnitude and number of lesions, if any, in fish collected downstream from the site were compared with fish collected from the reference area. In addition, the number and magnitude of lesions, if any, were correlated with surface water and sediment concentrations of the COPCs to determine if a dose-response relationship existed.

The third line of evidence to determine whether fish communities within the Bound Brook downstream of the site are potentially at risk were the results of two stream bioassessments, previously completed by the U.S. EPA (1992, 1993b), in which the fish communities inhabiting the Bound Brook were evaluated.

5.1.7.4 Measurement Endpoint for Assessment Endpoint #4: Protection of benthic invertebrate communities

Three lines of evidence were used to assess the effects of contamination within the Bound Brook on the benthic invertebrate communities that inhabit it. First, sediment samples were collected from seven locations along the Bound Brook (upstream, adjacent to, and downstream of the site) and analyzed for PCBs, pesticides, metals, BNAs, and VOCs. One sediment sample from each location was then used in a sediment toxicity test using *Hyalella azteca,* an amphipod. The results of the toxicity test were statistically analyzed to determine if survival or growth of the amphipod was adversely affected as compared to the reference area or the laboratory control. The results were then correlated to the measured concentrations of the COPCs in the sediment to determine if a dose-response relationship existed between the observed toxicity and any of the COPCs.

The second line of evidence to determine if contamination within the Bound Brook downstream of the site poses a potential risk to the benthic invertebrate community structure or function was the collection and analysis of crayfish from the Bound Brook adjacent to and downstream of the site. The results of the tissue analyses of the COPCs within the crayfish collected from the site were compared with literature values, if any, that have been associated with adverse effects.

The third line of evidence used to determine whether the benthic invertebrate communities within the Bound Brook downstream of the site are potentially at risk were the results of a stream bioassessment, previously completed by the U.S. EPA (1993c), in which benthic macroinvertebrate communities inhabiting the Bound Brook were evaluated.

5.1.7.5 Measurement Endpoint for Assessment Endpoint #5: Protection of amphibian populations, specifically through the protection of embryonic and larval stages

Two lines of evidence were originally established to assess the effects of contamination in the Bound Brook downstream of the site to amphibian populations. First, sediment samples were to be collected adjacent to and downstream of the site and used in a toxicological evaluation using frog embryos. This assay is a non-standardized assay and is currently under development. Due to problems in the development of the assay, the toxicological evaluation could not be conducted.

The second line of evidence that was to be used to evaluate the effects of contamination in the Bound Brook on amphibian populations was the collection and analysis of frogs from the Bound Brook adjacent to and downstream of the site. The results of the tissue analyses of the COPCs within the frogs was to be compared with literature values, if any, associated with adverse effects. However, the initial site reconnaissance indicated that sufficient numbers of frogs were not present at the site for such collection and analyses. Therefore, frogs were not collected for this purpose. Since neither line of evidence was able to be evaluated for the previous reasons, the potential risk from contamination within the Bound Brook downstream of the Cornell-Dubilier Electronics site to amphibian populations was not directly evaluated in this risk assessment.

5.1.7.6 Measurement Endpoint for Assessment Endpoint #6: Protection of insectivorous birds

A food chain accumulation red-winged blackbird model was employed using site specific data (sediment, water, and crayfish contaminant concentrations) to predict the rate of ingestion of the bioaccumulative COPCs by insectivorous birds. Crayfish were used as representative emergent aquatic insects consumed by red-winged blackbirds, since crayfish were collected, and aquatic emergent insects were not available in sufficient quantity for collection and analysis for the purpose of this food chain model. Therefore, crayfish were used to represent the contaminant pathway from the aquatic to the terrestrial ecosystem in this risk assessment. The contaminant ingestion rates calculated from the food chain model were then compared to literature values to determine if a potential risk to the survival and reproduction of insectivorous birds exists as a result of the contamination within the Bound Brook downstream of the Cornell-Dubilier Electronics site.

5.1.7.7 Measurement Endpoint for Assessment Endpoint #7: Protection of omnivorous birds

A food chain accumulation mallard duck model was employed using site specific data (sediment, water, and crayfish contaminant concentrations) to predict the rate of ingestion of the bioaccumulative COPCs by omnivorous birds. These contaminant ingestion rates were then compared to literature values to determine if a potential risk to the survival and reproduction of omnivorous birds exists as a result of the contamination within the Bound Brook downstream of the Cornell-Dubilier Electronics site.

5.1.7.8 Measurement Endpoint for Assessment Endpoint #8: Protection of piscivorus birds

A food chain accumulation green heron model was employed using site specific data (sediment, water, and fish contaminant concentrations) to predict the rate of ingestion of the bioaccumulative COPCs by piscivorus birds. These contaminant ingestion rates were then compared to literature values to determine if a potential risk to the survival and reproduction of piscivorus birds exists as a result of the contamination within the Bound Brook downstream of the Cornell-Dubilier Electronics site.

5.1.7.9 Measurement Endpoint for Assessment Endpoint #9: Protection of omnivorous mammals

Three lines of evidence were used to assess the effects of contamination within the Bound Brook and its stream corridor on the survival and reproduction of omnivorous mammals. The first line of evidence was the collection and analysis of white-footed mice within the Bound Brook stream corridor. The results of these tissue analyses were compared with literature values, if available, that have been associated with adverse effects.

The second line of evidence was the histopathological evaluation of livers and kidneys taken from a subsample of white-footed mice that were collected from the Bound Brook stream corridor. The histopathology results helped to determine whether or not any adverse pathological alterations, potentially due to chemical contamination, were manifested in the small mammal population within the stream corridor at the time of collection.

The third line of evidence was a food chain accumulation raccoon model that was employed using site-specific data (sediment, water, crayfish, and fish contaminant concentrations) to predict the rate of ingestion of the bioaccumulative COPCs by omnivorous mammals. These contaminant ingestion rates were then compared to literature values to determine if a potential risk to the survival and reproduction of omnivorous mammals exists as a result of the contamination within the Bound Brook downstream of the Cornell-Dubilier Electronics site.

5.1.7.10 Measurement Endpoint for Assessment Endpoint #10: Protection of carnivorous mammals

A food chain accumulation red fox model was employed using site-specific data (soil, water, and small mammal concentrations) to predict the rate of ingestion of the bioaccumulative COPCs by carnivorous mammals. These contaminant ingestion rates were then compared to literature values to determine if a potential risk to the survival and reproduction of carnivorous mammals exists as a result of the contamination along the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site.

5.2 Assumptions

The following conservative assumptions were made to conduct this risk assessment:

- Contaminants in food items were assumed to exhibit 100 percent absorption efficiency and were assumed not to be metabolized and/or excreted during the life of the receptor.

- Dietary composition information was obtained from the literature for the receptor species. However, simplifications of complex diets were assumed for the receptors. The contaminant dose was predicted on the basis of concentrations in food items that were actually measured.

- All area use factors were assumed to be one for all receptors evaluated in the food chain model for each location. Therefore, it was assumed that the receptors obtain 100 percent of their food from each location evaluated using the food chain model.

- Since most benchmark values were derived using dosing intervals shorter than seasonal life history events, breeding territories rather than full migratory ranges were used to calculate area use factors for birds. Therefore, it was assumed that avian receptors that are likely to spend a portion of the year in the contaminated area are present year-round.

- A literature search was conducted to determine the chronic toxicity of the contaminants of concern evaluated in the food chain model. In addition, acute toxicity values for PCBs, lead, and selenium were also obtained from the literature. If no toxicity values could be located for the receptor species, values reported for a closely related species were used. Studies were critically reviewed to determine whether the study design and methods were appropriate. If values for chronic toxicity were not available, LD50 (median lethal dose) values were used. For the purposes of this risk assessment, a factor of 100 was used to convert the reported LD50 to a No Observable Adverse Effect Level (NOAEL). A factor of 10 was used to convert a reported Lowest Observable Adverse Effect Level (LOAEL) to a NOAEL. If several toxicity values were reported for a receptor species, the most conservative value was used in the risk calculations as long as the study design, exposure route, mechanism, and species tested were deemed appropriate. For the chronic toxicity endpoints, values obtained from long-term feeding studies were used in preference to those obtained from single dose oral studies. No other safety factors were incorporated into this risk assessment.

- For the green heron, sediment ingestion rates could not be found in the literature. Therefore, estimated sediment ingestion rates were calculated based on reported dietary compositions and amounts of sediment/soil entrained in the digestive systems of prey items. In some cases, information on the entrainment of sediment/soil was unknown for certain prey items. Therefore, it was assumed that the dietary composition of the green heron consisted only of those species for which sediment/soil entrainment information had been reported. It was also assumed that the amount of sediment/soil entrained in prey items remained constant over time.
- In some cases, water and/or food ingestion rates were based on information for a similar species or calculated from an allometric equation. It was assumed that these estimated ingestion rates were representative of the true ingestion rates for the receptor species in question.

- In the food chain model, the lowest reported body weights for adults and the highest reported ingestion rates were assumed in each case.

- In some cases, toxicity values in the literature were reported as part per million (ppm), or milligrams per kilogram (mg/kg), contaminant in the diet. These were converted to daily intake (in milligrams per kilogram body weight per day; [mg/kg-day]) using the following formula:

  Daily Intake (mg/kg/day) = Contaminant Dose (mg/kg diet) x Ingestion Rate (kg/day) x 1/Bodyweight (kg)

  This conversion allowed dietary toxicity levels in the literature to be converted to a daily dose based on body weight. The body weight used for this conversion was the lowest reported body weight for an adult of the species in question, unless only a mean body weight was available. The lowest reported body weight was preferentially used to remain consistent with the use of the lowest reported body weight of the receptor species evaluated in the food chain model when calculating contaminant dosages.

- Due to data limitations and the feeding habits of the red-winged blackbird, it was assumed that incidental ingestion of sediment would be zero for this receptor species.

- To assess the potential risk of bioaccumulative COPCs, the concentrations of contaminants that belong to a class of chemicals (e.g., PCBs) were summed and treated as a total contaminant concentration for that class. In determining toxicity reference values for these contaminant classes, the lowest appropriate toxicity value was chosen to represent the toxicity of the entire class of that type of contaminant. In doing so, it was assumed that the total concentration of each class of contaminant consisted entirely of the most toxic member of that class.

- An original objective of this risk assessment was to collect emergent aquatic insects for analysis to use the resulting contaminant concentrations in the food chain model for insectivorous birds. However, the initial site investigation indicated that insects were not available in sufficient quantities for collection and analysis. Crayfish, on the other hand, were available in quantities much greater than expected and were thus collected and analyzed for COPCs. Since contaminant concentrations in insects were not available, the results of the crayfish analyses were used to represent insects in the food chain model for insectivorous birds. Because crayfish are benthic invertebrates, they were assumed to represent the pathway from the benthic to the terrestrial environment, a pathway that emergent aquatic insects would have represented had they been able to be collected.

- Some of the toxicity reference values (NOAELs and LOAELs) were derived from data for which dosages were only reported as dry weight, and the authors did not give enough information to convert them to wet weight. Therefore, it was assumed that the food administered in these studies consisted of 1/3 solids to convert the dosages to wet weight.

- For chlordane, the fish and crayfish tissue residue threshold values reported in the literature were reported as lipid-normalized concentrations. For the purposes of comparing these threshold values to measured tissue concentrations in the fish and crayfish collected for this risk assessment, which were not lipid-normalized, an overall mean percent lipids for both crayfish and fish were calculated from the analytical results of the crayfish and fish collected from the site. The resulting mean percent lipids were assumed to be representative of crayfish and fish, and were used to convert the lipid-normalized values reported in the literature to non-lipid-normalized values for the hazard quotient calculations.

- For selenium, the fish tissue residue threshold values reported in the literature were reported as dry weight concentrations. For the purposes of comparing these threshold values to measured tissue concentrations in the fish collected for this risk assessment, which were in wet weight, an overall mean percent solids for fish was calculated from the analytical results of the fish fillets collected from the site. The fish fillets were used, rather than whole body forage fish (pumpkinseeds), because the percent solids were only analyzed for the fish fillets. The resulting mean percent solids from the fillet tissue were assumed to be representative of percent solids in the whole body fish reported in the literature, and were used to convert the literature dry weight values to wet weight values for the hazard quotient calculations.

- In the food chain models for fish-eating receptors, the mean fish contaminant concentrations were calculated from whole body forage fish (pumpkinseed) data because this was the only species of fish for which whole body concentrations were analyzed. In addition to the analysis of whole body pumpkinseed, fillets were also taken and analyzed from pumpkinseed and many other species of fish to represent edible fish tissue for the purposes of a separate human health risk assessment. This fillet data set was combined with the whole body pumpkinseed data set to determine the maximum contaminant concentrations in fish for the purposes of the food chain models. Therefore, it was assumed that this combined data set (including the fillet tissue) is a representative data set to determine the maximum fish tissue concentration that a fish-consuming receptor would ingest.

5.3 Risk Characterization

5.3.1 Methods Used to Evaluate Risk

5.3.1.1 Use of Sediment Toxicity Tests to Evaluate Risk to Benthic Invertebrates

The results of the sediment toxicity test using *Hyalella azteca* were used to predict the effects of the sediment contamination downstream of the Cornell-Dubilier Electronics site with regard to the following assessment endpoint:

- Protection of benthic invertebrate communities

The toxicity test was used to determine the potential risk to the benthic invertebrate communities from the contamination within the Bound Brook and to determine which contaminants, of the COPCs identified in Section 5.1.2, potentially pose that risk. In addition, NOAEL and LOAEL values for each of the contaminants of concern were identified by comparing the measured levels of each contaminant in each sample to the toxicity of that sample. The resulting NOAELs and LOAELs provide a range below which the concentration of each contaminant is expected to be protective of the benthic invertebrate communities.

The sediment samples that were used for the toxicity test were collected from locations A1-1, A2-2, A3-1, A4-1, A5-2, A6-2, and A9-1 (Reference). The contaminant concentrations in these sediment samples were used to derive the NOAELs and LOAELs for benthic invertebrates.

5.3.1.2 Comparisons of Measured Tissue Concentrations to Literature Values

For the COPCs considered to be bioaccumulative in this risk assessment (all pesticides and PCBs, arsenic, cadmium, lead, mercury, and selenium), the literature was reviewed to identify whole body tissue concentrations that are associated with toxicity in crayfish, fish, and small mammals, the three ecological receptors that were collected and analyzed for the COPCs. For fish, the pumpkinseed was the only species evaluated in this manner because it was the only fish species in this risk assessment for which whole body concentrations of contaminants were measured.

The literature on toxicity-associated tissue levels is summarized in Appendix F. Where literature information was available, the mean and maximum whole body tissue concentrations of each bioaccumulative COPC were divided by the toxic threshold tissue concentration derived from the literature, resulting in a hazard quotient. A hazard quotient greater than one indicates a potential ecological risk.

This information contributed to the risk characterization for the following assessment endpoints:

- Protection of fish communities
- Protection of benthic invertebrate communities
- Protection of omnivorous mammals

5.3.1.3 Food Chain Models

The hazard quotient method (Barnthouse et al. 1986; U.S. EPA 1997a) was employed to predict the effects of contamination within the Bound Brook and its associated flood plains downstream of the Cornell-Dubilier Electronics site with respect to the following assessment endpoints:

- Protection of insectivorous birds
- Protection of omnivorous birds
- Protection of piscivorus birds
- Protection of omnivorous mammals
- Protection of carnivorous mammals

The hazard quotient method compares exposure concentrations to ecological endpoints such as mortality, reproductive failure or reduced growth. This is first done using chronic toxicity values derived from the literature that are intended to represent a lower dose over a longer duration of exposure, resulting in subtle effects that would be expected to manifest themselves at the population level over the longer term.

In addition, for those contaminants that resulted in a hazard quotient greater than one using the chronic LOAEL for any model and for any location, an acute hazard quotient was also calculated for that particular model and location using an acute toxicity value derived from the literature. These acute toxicity values are intended to represent a population-level effect that would be expected to manifest itself over a very short period of time (e.g., days).

The comparisons are expressed as ratios of potential intake values to population effect levels, as follows:

$$\text{Chronic Hazard Quotient} = \frac{\text{Exposure Concentration (Mean or Maximum)}}{\text{Chronic Effect Level (e.g., NOAEL or LOAEL)}}$$

$$\text{Acute Hazard Quotient} = \frac{\text{Exposure Concentration (Mean or Maximum)}}{\text{Acute Effect Level (e.g., LD50)}}$$

The effect level values for each COPC are based on studies published in the literature. These studies are summarized in Appendix F. The exposure concentrations were estimated by employing a food chain model for each measurement endpoint (e.g., the raccoon) associated with an assessment endpoint (e.g., omnivorous mammals). In these food chain models, ingestion rates of each contaminant of concern for each receptor species are determined based on measured concentrations of each contaminant in water, sediment/soil, and food items collected at the site as well as known or estimated water, sediment/soil, and food ingestion rates and body weights of each receptor species, which are summarized in Appendix G. The exposure concentrations and toxicity values are entered into the hazard quotient equation, and a hazard quotient is calculated. If the hazard quotient is greater than one based on a chronic NOAEL, this indicates that there is a potential chronic risk from that contaminant to the ecological receptor in question. If the hazard quotient is greater than one based on a chronic LOAEL for a particular contaminant, this indicates that the site levels of that contaminant have the potential to produce an actual adverse effect on survival, reproduction, or growth of the ecological receptor in question. If the hazard quotient for a particular contaminant is greater than one based on an acute value, this indicates that there is a potential risk from that contaminant to the ecological receptor in question over the very short-term. The hazard quotient should be interpreted based on the severity of the effect reported.

In addition to determining which contaminants pose a potential risk to the assessment endpoints, the food chain model was also used to develop preliminary ecotoxicologically-based soil and sediment remedial goals, when possible. To do this, the soil or sediment concentration of each contaminant that resulted in a hazard quotient just over one using the mean water and biota concentrations in the food chain model was selected for each receptor. This was performed for both the NOAEL and the LOAEL. An overall preliminary ecotoxicologically-based remedial goal was then established, if possible, for each contaminant of concern by selecting the lowest NOAEL and the lowest LOAEL across all the receptors. The resulting NOAEL and LOAEL soil and sediment values provide a range between which the soil and sediment concentrations of the contaminants would no longer be expected to pose a risk to any of the assessment endpoints evaluated in the food chain model.

For the purposes of this risk assessment, both mean and maximum contaminant exposure scenarios were modeled for each location. To model the maximum contaminant exposure scenario, the maximum water, soil/sediment, and food concentrations were entered into the food chain model to estimate a maximum contaminant dose for each location for each receptor species. Likewise, to model the mean exposure scenario, the mean measured concentrations in water, soil/ sediment, and biota were entered into the food chain models to estimate a mean contaminant dose for each location for each receptor species. When fish were used as a food item, mean contaminant fish levels were calculated from whole body forage fish (pumpkinseed) concentrations only. Maximum contaminant concentrations in fish were determined by taking the maximum concentration detected in any fish sample, including fillets, for all fish species analyzed for each location. The values that were used in the models for each contaminant at each location are summarized in Tables 39 to 45.

The soil, sediment, and food items were entered into the models as wet weight concentrations to be compared to the toxicity values derived from the literature, which were also entered into the models on a wet weight basis. In addition, the water concentrations entered into the models were for unfiltered water only because this represents a more realistic exposure via oral ingestion of water.

5.3.1.4 Other Lines of Evidence

5.3.1.4.1 Observations of Fish Lesions

In addition to comparing fish tissue concentrations to values reported in the literature that were associated with toxic effects, an additional method was used to assess the potential risk of contamination in the Bound Brook downstream of the Cornell-Dubilier Electronics site to the following assessment endpoint:

- Protection of fish communities

The magnitude and number of abnormalities, such as lesions, in the fish that were collected from the Bound Brook downstream of the site for this risk assessment were observed during their collection and processing. The results were used to assist in the determination of potential risk posed to the fish communities within the Bound Brook.

5.3.1.4.2 Results of Stream Bioassessments

The results of two stream bioassessments, previously completed by the U.S. EPA (1992, 1993b), in which fish communities inhabiting the Bound Brook were evaluated, were used as a third line of evidence to assess the potential risk of contamination in the Bound Brook downstream of the Cornell-Dubilier Electronics site to the following assessment endpoint:

- Protection of fish communities

In addition, the results of another stream bioassessment (U.S. EPA 1993c) in which benthic macroinvertebrate communities inhabiting the Bound Brook were evaluated, were used as a third line of evidence to assess the potential risk of contamination in the Bound Brook downstream of the Cornell-Dubilier Electronics site to the following assessment endpoint:

- Protection of benthic invertebrate communities

5.3.1.4.3 Histopathological Examinations of Small Mammal Kidneys and Livers

In addition to using the food chain model as well as comparing small mammal tissue concentrations to literature values associated with toxicity, one additional method was used to assess the potential risk of contamination in the Bound Brook stream corridor to the following assessment endpoint:

- Protection of omnivorous mammals

Histopathological evaluations of the livers and kidneys taken from a subsample of white-footed mice collected for this risk assessment were performed. The results of these evaluations were used to assist in determining whether a potential risk is posed to omnivorous mammals in the Bound Brook stream corridor downstream of the site.

5.3.1.5 Treatment of the Data

Many of the pesticides evaluated in this risk assessment are actually metabolites or break-down products of a parent pesticide (e.g., DDT, DDD, and DDE). In other cases, studies in the literature report results for only the class of compounds rather than its specific members (e.g., PCBs). Finally, some contaminants are actually mixtures of isomers of the same chemical (e.g., a-chlordane and g-chlordane). Therefore, members of these classes of chemicals were grouped into one class by summing them to provide a total concentration for each chemical class (e.g., total PCBs). For these classes, the resulting total concentrations were evaluated in this risk assessment to determine the potential risk posed by these chemicals. When deriving toxicity benchmarks from the literature for these classes of chemicals, the lowest reported ecologically relevant toxicity value was selected as representative of each class. Therefore, each class of chemicals is assumed to contain 100 percent of the most toxic metabolite, isomer, or congener. The contaminants that were treated as classes of compounds and summed to derived a "total" concentration for that class are as follows:

α-chlordane + ς-chlordane = total chlordane

DDT + DDD + DDE = total DDT
endrin + endrin aldehyde + endrin ketone = total endrin
PCB-1248 + PCB-1254 = total PCBs
heptachlor + heptachlor epoxide = total heptachlor

In addition, when mean and maximum contaminant concentrations in water, soil, sediment, and biota were calculated for the COPCs to evaluate their potential risk, conservative assumptions were made to account for "non-detect" results. For example, when an inorganic COPC was not detected in a particular sample, it was assumed that the actual concentration of that COPC in that sample was one-half the detection limit. Similarly, if an organic COPC was not detected in a sample, it was assumed that the actual concentration of that COPC in that sample was one-tenth the detection limit. These assumptions were also made when chemicals belonging to a common class of chemicals (e.g., PCBs) were summed to get a "total" concentration, as described previously. For example, if PCB-1254 was detected in a sample, but PCB-1248 was not, the "total PCB" concentration of that sample was calculated by summing the PCB-1254 concentration detected in the sample plus one-tenth of the detection limit of PCB-1248 for that sample. Therefore, even if a particular contaminant of concern was not detected in any of the samples for a particular matrix, data for that contaminant in that matrix were still evaluated in this risk assessment by assuming that the contaminant is actually present in each sample of that matrix at one-tenth (for organics) or one-half (for inorganics) of the detection limit for that particular contaminant.

5.3.2 Results and Discussion of the Hazard Evaluation

5.3.2.1 Protection of the structure and function of the stream

The overall functioning of the stream communities in the Bound Brook was inferred through the evaluation of assessment endpoints 3, 4, 5, 6, 7, 8, and 9. Overall, the structure and function of the stream communities downstream of the Cornell-Dubilier Electronics site are at risk from site-related chemical contamination. First, a risk is posed to the benthic community and is potentially due to a variety of VOCs and BNAs detected in the sediment, as well as silver, calcium, copper, vanadium, zinc, and dieldrin. The fish within the stream were determined to be at risk from exposure to selenium and PCBs, but the risk posed by the other bioaccumulative COPCs could not be determined. Birds utilizing the stream were determined to be potentially at risk from lead, total PCBs, total endrin, total chlordane, and total DDT. Finally, a potential risk to omnivorous mammals using the stream was found to be posed by methoxychlor, arsenic, mercury, total PCBs and selenium.

5.3.2.2 Protection of the structure and function of the stream corridor

The overall functioning of the Bound Brook stream corridor was inferred through the evaluation of assessment endpoints 5, 6, 7, 8, 9, and 10. Overall, the structure and function of the stream corridor downstream of the Cornell-Dubilier Electronics site is at risk from chemical contamination. First, birds utilizing the stream corridor were determined to be potentially at risk from lead, total PCBs, total endrin, total chlordane, and total DDT. A potential risk to omnivorous mammals using the stream was found to be posed by methoxychlor, arsenic, mercury, total PCBs and selenium. Finally, a potential risk to carnivorous mammals was also found to be posed by total PCBs.

5.3.2.3 Protection of fish communities

Literature values on the toxicity of whole body contaminant concentrations in fish were only available for chlordane, total PCBs, mercury, and selenium. The hazard quotients that resulted from comparing measured whole body concentrations of these COPCS with their associated literature toxicity threshold values are summarized in Table 46. Of these four contaminants, total chlordane and mercury concentrations in pumpkinseed did not exceed their threshold concentrations at any location when both the mean and the maximum measured tissue concentrations were used. Therefore, no risk to fish from total chlordane or mercury was calculated.

The mean and maximum whole-body concentrations of selenium exceeded the toxic threshold concentration at locations A1 through A5 (indicating a hazard quotient >1). Only the maximum whole-body concentration exceeded the toxic threshold concentration at location A6.

The maximum whole-body concentration of total PCBs exceeded the toxic threshold concentration at locations A1 through A6. Also, the mean whole-body concentration of total PCBs exceeded the toxic threshold concentration at locations A2 and A3.

Since threshold values for the remaining COPCs could not be found in the literature, the risk from methoxychlor, dieldrin, total endrin, total heptachlor, total DDT, arsenic, cadmium, and lead to fish could not be determined using this method of evaluation.

The results of the stream bioassessments conducted by the U.S. EPA (1992, 1993b) indicated that fish species richness and total abundance at sample locations adjacent to and downstream (directly below New Market Pond) of the site are extremely low, demonstrating that the fish communities in this section of the Bound Brook have been adversely affected. Although this condition is not linked to any particular cause, it is possible that the contamination present in the Bound Brook adjacent to and downstream of the site has at least contributed to the downgrade of fish community health in this water body.

When fish were observed during collection and processing, no abnormalities (e.g., lesions) were noted. Therefore, this measurement endpoint did not contribute to an evaluation of risk to fish communities in the Bound Brook downstream of the Cornell- Dubilier site.

It appears as if the fish communities within the Bound Brook adjacent to and downstream of the Cornell-Dubilier Electronics site have been adversely affected. This may be due, at least in part, to the contamination within the stream. Selenium and total PCBs were found to pose a potential risk to fish, since selenium and total PCB concentrations in fish tissue were found to be higher than those found in the literature to be associated with toxic effects. Therefore, it is likely that selenium and/or PCBs are contributing to the observed population-level effects. In addition, since the risk from methoxychlor, dieldrin, total endrin, total heptachlor, total DDT, arsenic, cadmium, and lead to fish could not be determined using this method of evaluation, it is possible that any of these contaminants may also pose a potential risk to fish in the Bound Brook.

5.3.2.4 Protection of benthic invertebrate communities

Literature values on the toxicity of whole body contaminant concentrations in crayfish were only available for total chlordane and total PCBs. The hazard quotients that resulted from comparing measured whole body concentrations of these COPCs with their associated literature toxicity threshold values are summarized in Table 47. For these two contaminants, neither the mean nor the maximum measured whole body crayfish concentrations of either of these contaminants exceeded their toxic threshold. This was true for every location from which crayfish were collected (locations A1 through A5). Therefore, no risk to crayfish from total chlordane or total PCBs was calculated for crayfish at these locations.

Since threshold values for the remaining COPCs could not be found in the literature, the risk to crayfish from methoxychlor, dieldrin, total endrin, total heptachlor, total DDT, arsenic, cadmium, lead, mercury, and selenium could not be determined using this method of evaluation.

The results of the sediment toxicity test are presented in Table 29 and indicate that none of the locations exhibited a reduction in growth of *Hyalella azteca*. However, the sediment sample collected from location A3 caused a statistically significant reduction in survival of *Hyalella azteca* when compared to the reference area (A9). None of the other samples exhibited a statistically significant difference in survival compared to the reference. Although the percent survival for location A3 (76.7 percent) was statistically lower than the reference, it was not drastically different from some of the other locations evaluated that were not determined to be statistically different from the reference. For example, only 82.5 percent survival was observed at location A5. Nevertheless, an evaluation of the contaminants that may have produced the observed toxicity at location A3 was performed. To determine whether a particular contaminant of concern had potentially contributed to the observed toxicity, the concentration of that contaminant in the sample from location A3-1 was compared to its concentration in all the other samples evaluated in the test. If the concentration of the contaminant in the sample from location A3-1 was greater than its concentration in all other samples used in the toxicity test, then that contaminant was determined to have potentially contributed to the observed toxicity. For each contaminant that was determined to have potentially contributed to the observed toxicity, the NOAELs and LOAELs for mortality were determined. The maximum concentration of a contaminant in all tested samples other than that from location A3-1 was determined to be the mortality NOAEL for that contaminant. The contaminant concentration measured in the sediment sample from location A3-1 was determined to be the mortality LOAEL for that contaminant. The COPCs that were determined to potentially pose a risk to benthic invertebrates, as well as their associated mortality NOAELs and LOAELs, are presented in Table 48.

The results of the stream bioassessment conducted by the U.S. EPA (1993c) indicated that the macroinvertebrate community has been severely impacted directly adjacent to the site according to all of the indices that were measured (total taxa richness, EPT richness, percent dominance, percent EPT, biotic index, and water quality assessment). In addition, these indices indicated that further downstream of the site, the macroinvertebrate community has been moderately to severely impacted. Although these findings are not linked to any particular cause, it is possible that the contamination present in the Bound Brook adjacent to and downstream of the site has at least contributed to the downgrade of macroinvertebrate community health in this water body.

Overall, the results of these evaluations indicate that a potential risk is posed to benthic invertebrate community structure and function from methylene chloride, acetone, toluene, carbon disulfide, benzidine, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, di-n-octyl phthalate, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, benzo(ghi)perylene, silver, calcium, copper, vanadium, zinc, and dieldrin.

5.3.2.5 Protection of insectivorous birds

The food chain model and chronic hazard quotient calculations for insectivorous birds are presented in Tables 49 to 53. For locations A1, A2, and A5, using the maximum concentrations for each contaminant of concern and the NOAEL, it was determined that a potential risk is associated with total PCBs and lead in the Bound Brook downstream of the Cornell-Dubilier Electronics site. The mean and the NOAEL also indicated such a risk. Using both the mean and the maximum concentrations with the LOAELs, no risk was calculated from any contaminant.

For locations A3 and A4, when the maximum concentrations of each contaminant of concern and the NOAELs were used, a potential risk was calculated for total endrin, total PCBs, and lead. When the mean and the NOAEL were used, a potential risk was still calculated for total PCBs, but no longer for total endrin or lead. When both the mean and the maximum contaminant concentrations were used with the LOAEL, no risk was calculated for any contaminant.

Since no risk was calculated for any contaminant at any location when either the mean or the maximum was used with the LOAELs, the evaluation of an acute risk to insectivorous birds utilizing the Bound Brook stream corridor downstream of the site was not necessary.

Preliminary ecotoxicologically-based sediment remedial goals could not be determined based on the insectivorous bird model because it was assumed for the purposes of the model that the red-winged blackbird does not incidentally ingest any sediment. Therefore, the sediment concentrations in this model had no influence on the outcome of the hazard quotients.

Nevertheless, a preliminary ecotoxicologically-based sediment remedial goal would not have been able to have been determined for total endrin for a variety of reasons, the most important of which is the fact that neither endrin nor any of its derivatives were detected in sediment at any of the locations evaluated in the risk assessment. Therefore, it would be unrealistic to determine a sediment remedial goal below the detection limit for these compounds. Second, since total endrin only resulted in a hazard quotient greater than one when the maximum contaminant concentrations were used, and sediment remedial goals are only established using mean contaminant concentrations, a sediment remedial goal would not have been able to be established anyway. Furthermore, a hazard quotient of greater than one was only calculated for total endrin when the NOAEL, not the LOAEL, was used. Therefore, even if the maximum contaminant concentrations were used to establish remedial goals, the total endrin concentrations would have already been within the remedial goal range (between the NOAEL and the LOAEL). Finally, since the hazard quotients that exceeded one for total endrin (at locations A3 and A4) were relatively low (1.4 and 1.1, respectively), it is not likely that total endrin presents a significant risk to insectivorous birds at the site.

For lead and total PCBs, a preliminary ecotoxicologically-based sediment remedial goal could not be determined because the sediment concentrations of these two contaminants did not correlate with their hazard quotients. This fact is particularly interesting because it indicates that the concentrations of lead and total PCBs in the sediment did not correlate well with lead and total PCB concentrations in crayfish. This is because crayfish were by far the primary source of exposure to lead and total PCBs in the model since the surface water concentrations in the model were extremely low, and as stated previously, it was assumed for the purposes of the model that the red-winged blackbird does not ingest sediment. For lead, bioaccumulation from sediment to crayfish did not appear to be significant. For total PCBs, although bioaccumulation and biomagnification were apparent, no clear trend from sediment to crayfish could be established. This may have been because the sediment samples may not have been good representative samples from each location or because the sediment samples may have been heterogeneous in nature, or it may simply be due to the fact that unknown factors are controlling the bioaccumulation processes of PCBs in crayfish.

The sediment concentration of lead at the reference area (A9) was well within and at the high end of the range of sediment concentrations downstream of the Cornell-Dubilier Electronics site. Additionally, the mean crayfish concentration of lead at the reference area was greater than the mean crayfish concentration of lead at all of the locations evaluated in the insectivorous bird food chain model (A1 - A5). This indicates that the sediment lead concentrations downstream of the site are not entirely site-related. Furthermore, lead may not pose a substantial risk to insectivorous birds, as evidenced by the relatively low hazard quotients that resulted from using the mean water and biota concentrations in the food chain model (1.2, 1.3, <1, <1, and 1.5).

Furthermore, since no risk was calculated for lead when the LOAEL was used in the food chain model for insectivorous birds, the mean sediment concentrations at each location are already currently within the range between the NOAEL and the LOAEL. Therefore, the current sediment concentrations of lead would already be within the preliminary remedial goal range for lead had one been established.

With regard to PCBs, none were detected in the sediment collected from the reference area. In crayfish, PCBs were detected in only one of 10 crayfish samples from the reference area, but PCBs were detected in all of the crayfish samples collected downstream of the site. This indicates that PCBs are site-related. However, the hazard quotients that were calculated using the mean water and biota contaminant concentrations and the NOAEL in the food chain model for insectivorous birds were relatively low (1.8 to 4.2), indicating that PCBs may not pose a substantial risk to insectivorous birds utilizing the Bound Brook corridor downstream of the site. Furthermore, since no risk was calculated for total PCBs when the LOAEL was used in the food chain model for insectivorous birds, the mean sediment concentations at each location are already currently within the range between the NOAEL and the LOAEL for PCBs. Therefore, the current sediment concentrations of PCBs would already be within the preliminary remedial goal range for total PCBs had one been established.

Overall, the results of the food chain evaluation for insectivorous birds indicates that a potential risk is posed to insectivorous birds from total endrin, total PCBs, and lead. Although no preliminary ecotoxicologically-based sediment remedial goals could be established for these contaminants to protect insectivorous birds, their hazard quotients were relatively low, and their sediment concentrations would already be within the preliminary remedial goal ranges for these contaminants had they been established.

5.3.2.6 Protection of omnivorous birds

The food chain model and chronic hazard quotient calculations for omnivorous birds are presented in Tables 54 to 58. For all locations evaluated (A1 through A5), using the maximum concentrations of each contaminant of concern and the NOAEL, it was determined that a potential risk is associated with lead in the Bound Brook downstream of the Cornell-Dubilier Electronics site. The mean and the NOAEL also indicated such a risk for all five locations. When the maximum concentrations and the LOAELs were used, no risk was calculated at any location for any contaminant except for location A4, where lead still presented a potential risk. When the mean and the LOAELs were used, no risk was calculated for any of the locations for any of the contaminants.

Since the maximum lead concentrations at location A4 exceeded the LOAEL for omnivorous birds, the acute risk from lead to omnivorous birds was evaluated for this location using the food chain model. The results of this evaluation are presented in Table 59 and indicate that no acute risk is posed by lead to omnivorous birds utilizing the Bound Brook downstream of the Cornell-Dubilier Electronics site.

A preliminary ecotoxicologically-based sediment remedial goal was able to be determined for lead using the omnivorous bird model, as opposed to the insectivorous bird model, because the sediment lead concentrations in the omnivorous bird model correlated nicely with the hazard quotients for lead from location to location. This was due to the fact that, at all locations except A5, the model calculated a dosage of lead resulting from the incidental ingestion of sediment to be approximately four to six times the dosage from the ingestion of crayfish. At location A5, the sediment lead concentration was significantly lower than at the other locations, resulting in a dosage from incidental sediment ingestion to be slightly lower than the dosage calculated from the ingestion of crayfish. Nonetheless, the overall dosage at location A5 was still calculated to be the lowest dosage of all locations, thereby maintaining the correlation between sediment concentrations and hazard quotients across the locations.

A sediment lead concentration of 28 mg/kg, dry weight, was determined to be the lower boundary (NOAEL) of the preliminary ecotoxicologically-based remedial goal range because it was the mean sediment lead concentration that resulted in the hazard quotient that was closest to one (2.8). Since the LOAEL was not exceeded using the mean lead concentrations in the model, the sediment concentrations were determined to be already below the upper boundary (LOAEL) of the preliminary ecotoxicologically-based remedial goal range, and thus a sediment LOAEL was not determined.

Although a sediment NOAEL of 28 mg/kg, dry weight, was established for lead for omnivorous birds, this sediment concentration is much lower than the mean sediment lead concentration of 185 mg/kg, dry weight, at the reference area (A9). This indicates that the sediment lead concentrations downstream of the site are not entirely site-related. Furthermore, since no risk was calculated for lead when the LOAEL was used in the food chain model for omnivorous birds, the mean sediment concentrations at each location are already currently within the preliminary ecotoxicologically-based remedial goal range for omnivorous birds.

Overall, the results of the food chain evaluation for omnivorous birds indicate that a potential risk is posed to omnivorous birds from lead. Although the lower boundary of the preliminary ecotoxicologically-based sediment remedial goal range was determined to be 28 mg/kg, dry weight, to protect omnivorous birds, this concentration is much lower than the mean sediment concentration measured at the reference area (A9). Furthermore, the mean sediment lead concentrations downstream of the site are currently already within the preliminary ecotoxicologically-based remedial goal range.

5.3.2.7 Protection of piscivorus birds

The food chain model and chronic hazard quotient calculations for piscivorus birds are presented in Tables 60 to 65. For location A1, using the maximum concentrations of each contaminant of concern and their NOAELs, it was determined that a potential risk is associated with total chlordane, total endrin, total DDT, total PCBs, and lead at this location. When the mean and the NOAELs were used, a potential risk was calculated for total endrin and total PCBs. When the maximum and the LOAELs were used, total PCBs was the only COPC for which a potential risk was calculated. When the mean and the LOAELs were used, no risk was calculated from any contaminant at location A1.

For locations A2, A3, and A4, when the maximum contaminant concentrations and the NOAELs were used, a potential risk was calculated from total endrin, total PCBs and lead. When the mean and the NOAELs were used, a potential risk was still calculated from total endrin and total PCBs, but not from lead. When both the mean and the maximum contaminant concentrations and the LOAELs were used, a potential risk was presented only from total PCBs.

For location A5, when the maximum contaminant concentrations and the NOAELs were used, a potential risk was calculated for total endrin and total PCBs at both locations. When the mean and the NOAELs were used, a potential risk was calculated only for total PCBs. Similarly, when the LOAELs and both the mean and the maximum contaminant concentrations were used, a potential risk was calculated only for total PCBs at this location.

Finally, for location A6, when the maximum contaminant concentrations and the NOAELs were used, a potential risk was calculated from total endrin, total DDT, total PCBs, and lead. When the mean and the NOAELs were used, a potential risk was still calculated from total endrin, total

PCBs and lead, but no longer from total DDT. When the LOAELs and the maximum contaminant concentrations were used, a potential risk was only calculated from total PCBs. Finally, when LOAELs and the mean contaminant concentrations were used, no risk was calculated from any contaminant of concern.

Since the PCB dosages calculated from the model exceeded the chronic LOAEL for piscivorus birds at every location evaluated, the acute risk from total PCBs to piscivorus birds was also evaluated using the food chain model. The results of this evaluation are presented in Table 66 and indicate that no acute risk is posed by total PCBs to piscivorus birds utilizing the Bound Brook downstream of the Cornell-Dubilier Electronics site.

A preliminary ecotoxicologically-based sediment remedial goal was not determined for total chlordane, total endrin, or total DDT for a variety of reasons. First, these three pesticides were not detected in the sediment at any location with the exception of location A7, where 4,4'-DDD was detected at a concentration of only 0.03 mg/kg (estimated), dry weight. Since these contaminants were also not detected in surface water, this indicates that the exposure route of these contaminants to piscivorus birds in the model was via ingestion of fish. Since fish appear to be accumulating these contaminants even though they were not detected in sediment or water downstream of the Cornell-Dubilier Electronics site, this indicates that these contaminants are probably not site-related and are potentially derived from another source. Regardless, the dosages calculated by the model for two of these contaminants (total chlordane and total DDT) resulted in hazard quotients exceeding one only when the maximum, not the mean, contaminant concentrations were used. Furthermore, for all three of these contaminants, the dosages calculated by the model resulted in hazard quotients greater than one only when the chronic NOAELs, not the LOAELs, were used. Finally, the only hazard quotients that did exceed one for these three pesticides were relatively low, ranging from 1.1 to 9.4. Therefore, the weight of

evidence suggests that these three pesticides, although a potential risk to piscivorus birds, do not appear to present a significant risk, and furthermore they do not appear to be site-related.

For lead, the lower boundary of a preliminary ecotoxicologically-based sediment remedial goal was able to be determined using the green heron model because a hazard quotient of greater than one (1.1) using the mean lead concentrations and the chronic NOAEL was calculated for one location (A6). The lead concentration that resulted in this hazard quotient was 250 mg/kg, dry weight. Therefore, the lower boundary (NOAEL) of the preliminary ecotoxicologically-based sediment remedial goal was determined to be 250 mg/kg, dry weight, for the protection of piscivorus birds. Since the chronic LOAEL was not exceeded using the mean lead concentrations at any location, the current sediment lead concentrations are already below the upper boundary (LOAEL) of the preliminary ecotoxicologically-based sediment remedial goal range, thus the upper boundary was not determined. Furthermore, the only hazard quotient that exceeded one using mean lead concentrations was only 1.1, and therefore at the very low end of the preliminary ecotoxicologically-based remedial goal range.

For PCBs, a preliminary ecotoxicologically-based remedial goal could not be determined using the green heron model because the sediment concentrations of PCBs did not correlate with the resulting hazard quotients from location to location. This indicates that the PCB concentrations in the sediment did not correlate well with PCB concentrations in fish, since fish were used as the sole food item for the green heron in the model. Although the fish had evidently accumulated PCBs in their tissues, no clear trend from sediment to fish could be established. As discussed previously (Section 5.3.2.5), this may have been because the sediment samples may not have been good representative samples from each location or possibly because the sediment samples may have been heterogeneous in nature. Other explanations include the possibility that unknown factors are controlling the bioaccumulation processes of PCBs in fish or that additional sources of PCBs are present and are acting as additional routes of exposure of fish to PCBs downstream of the Cornell-Dubilier Electronics site. Since a preliminary ecotoxicologically-based sediment remedial goal could not be established for PCBs using the green heron model, and since some of the sediment PCB concentrations resulted in hazard quotients greater than one using the LOAEL, source control is necessary at a minimum to reduce the risk of PCBs to piscivorus birds inhabiting the Bound Brook stream corridor downstream of the site.

Overall, the results of the food chain evaluation indicate that a potential risk is posed to piscivorus birds utilizing the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site from total chlordane, total endrin, total DDT, total PCBs, and lead. However, since chlordane, endrin, and DDT were not detected in any of the sediment samples collected from the Bound Brook downstream of the site, with the exception of one sample from location A7, in which 0.03 mg/kg of DDD was detected, these three pesticides were deemed not to be site-related and therefore, no preliminary ecotoxicologically-based remedial goals were established for these pesticides. For lead, the lower boundary of the preliminary ecotoxicologically-based sediment remedial goal range was determined to be 250 mg/kg, dry weight, for the protection of piscivorus birds. However, the mean sediment lead concentrations downstream of the site are already currently within and at the low end (close to the NOAEL) of the preliminary ecotoxicologically-based remedial range. For PCBs, a preliminary ecotoxicologically-based sediment remedial goal range could not be determined because the mean sediment

PCB concentrations did not correlate with the resulting hazard quotients. Therefore, source control of PCBs is recommended at a minimum for the protection of piscivorus birds from the risk posed by PCBs downstream of the site.

5.3.2.8 Protection of omnivorous mammals

The food chain model and chronic hazard quotient calculations for omnivorous mammals are presented in Tables 67 to 72. For location A1, using the maximum concentrations of each contaminant of concern and their NOAELs, it was determined that a potential risk is associated with methoxychlor, total PCBs, arsenic, mercury, and selenium. When the mean and the NOAELs were used, a potential risk was only calculated from total PCBs and selenium. Similarly, when the maximum and the LOAELs were used, total PCBs and selenium were the only COPCs for which a potential risk was calculated. When the mean and the LOAELs were used, selenium was the only contaminant of concern for which a potential risk was calculated.

For locations A2, A4, and A6, using the maximum concentrations of each contaminant and their NOAELs, a potential risk from total PCBs, mercury, and selenium was calculated. When both the mean and the NOAELs and the maximum concentrations and the LOAELs were used, a potential risk was calculated from only total PCBs and selenium. When the mean concentrations and the LOAELs were used, a potential risk from only selenium was calculated. It should be noted that for location A6, raccoons were assumed to consume 100 percent fish, rather than 50 percent crayfish and 50 percent fish, which were assumed at all the other locations. This is because crayfish were not collected at location A6.

For locations A3 and A5, using the maximum concentrations of each contaminant and their NOAELs, a potential risk from total PCBs, arsenic, mercury, and selenium was calculated. When both the maximum and the LOAELs and the mean concentrations and the NOAELs were used, a potential risk was calculated from only total PCBs and selenium. When the mean concentrations and the LOAELs were used, a potential risk from only selenium was still calculated.

Since the total PCB and selenium dosages calculated from the model exceeded their chronic LOAELs for omnivorous mammals at every location evaluated, the acute risk from total PCBs and selenium to omnivorous mammals was also evaluated using the food chain model. The results of this evaluation are presented in Table 73 and indicate that no acute risk is posed by total PCBs or selenium to omnivorous mammals utilizing the Bound Brook downstream of the Cornell-Dubilier Electronics site.

A preliminary ecotoxicologically-based sediment remedial goal was not determined for methoxychlor for a variety of reasons. First, this pesticide was not detected in the sediment at any location downstream of the Cornell-Dubilier Electronics site. Since this contaminant was also not detected in surface water or crayfish, this indicates that the exposure route of methoxychlor to omnivorous mammals in the model was via ingestion of fish. Since fish appear to be accumulating methoxychlor even though it was not detected in sediment or water downstream of the Cornell-Dubilier Electronics site, this indicates that methoxychlor is probably not site-related and is potentially derived from another source. In addition, methoxychlor resulted in a hazard quotient exceeding one at only one location (A1), and the hazard quotient was very low (1.4). Finally, the hazard quotient exceeded one only when the maximum, not the mean, contaminant concentration was used and only when the chronic NOAEL, not the LOAEL, was used. Therefore, the weight of evidence suggests that methoxychlor, although a potential risk to omnivorous mammals, does not appear to present a significant risk, and furthermore it does not appear to be site-related.

For arsenic and mercury, preliminary ecotoxicologically-based sediment remedial goals were also not determined. This was because remedial goals are established using the mean contaminant concentrations in the food chain models, and the hazard quotients for arsenic and mercury exceeded one only when the maximum, not the mean, contaminant concentrations were used. Therefore, the mean arsenic and mercury sediment concentrations downstream of the Cornell-Dubilier Electronics site are already below what would have been the ecotoxicologically-based sediment remedial goal for omnivorous mammals, had one been established. It should also be noted that the hazard quotients that were greater than one for these two contaminants were relatively low, ranging from 1.1 to 4.5.

For total PCBs and selenium, preliminary ecotoxicologically-based remedial goals could not be determined using the omnivorous mammal model because the sediment concentrations of total PCBs and selenium did not correlate with their resulting hazard quotients from location to location. This indicates that total PCB and selenium concentrations in the sediment did not correlate well with total PCB and selenium concentrations in crayfish and/or fish, even though the crayfish and fish had evidently accumulated PCBs and selenium in their tissues. As discussed previously (Section 5.3.2.5), this may have been because the sediment samples may not have been good representative samples from each location or possibly because the sediment samples may have been heterogeneous in nature. Other explanations include the possibility that unknown factors are controlling the bioaccumulation processes of PCBs and selenium in crayfish and/or fish or that additional sources of PCBs and selenium are present and are acting as additional routes of exposure of crayfish and/or fish to PCBs and selenium downstream of the Cornell-Dubilier Electronics site. Since a preliminary ecotoxicologically-based sediment remedial goal could not be established for total PCBs or selenium using the omnivorous mammal model, and since some of the sediment total PCB and selenium concentrations resulted in hazard quotients greater than one using the LOAEL, source control is necessary at a minimum to reduce the risk of PCBs and selenium to omnivorous mammals inhabiting the Bound Brook stream corridor downstream of the site.

A second line of evidence to evaluate the potential risk of contamination within the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site to omnivorous mammals was the comparison of measured small mammal (white-footed mouse) whole body concentrations of the COPCs to those in the literature that have been associated with toxic effects. However, since no information was found in the literature in which small mammal whole body concentrations of the bioaccumulative COPCs were associated with toxic effects, the risk from total PCBs, total chlordane, methoxychlor, dieldrin, total endrin, total heptachlor, and total DDT could not be determined using this method of evaluation. Furthermore, since small mammals were not analyzed for TAL metals for this risk assessment, the potential risk posed to omnivorous mammals from arsenic, cadmium, lead, mercury, and selenium could not be determined using this method of evaluation.

A third line of evidence to evaluate the potential risk of contamination within the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site to omnivorous mammals was a histopathological evaluation of livers and kidneys taken from a subsample of small mammals (white-footed mice) collected for this risk assessment. The histopathological report is presented in Appendix H. The results indicate that many of the livers, primarily from location T1, exhibited large numbers of parasites or parasite eggs. The report states that this was probably due to a heavy environmental parasitic load in this area. This could not be attributed to any particular contaminant in the study area. Therefore, the report does not indicate any abnormal pathological findings that could be attributed to any particular chemical contamination at the site.

Overall, the results of the food chain evaluation indicate that a potential risk is posed to omnivorous mammals utilizing the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site from methoxychlor, total PCBs, arsenic, mercury, and selenium. However, since methoxychlor was not detected in any of the sediment samples collected from the Bound Brook downstream of the site, this pesticide was deemed not to be site-related and therefore, no preliminary ecotoxicologically-based remedial goal was established for methoxychlor. For arsenic and mercury, a preliminary ecotoxicologically-based remedial goal was also not established because a hazard quotient of greater than one was only established for these contaminants when the maximum contaminant concentrations were used. Therefore, their sediment concentrations are already below what would have been the preliminary ecotoxicologically-based sediment remedial goal had one been established. For PCBs and selenium, a preliminary ecotoxicologically-based sediment remedial goal range could not be determined because the mean sediment PCB and selenium concentrations did not correlate with their resulting hazard quotients. Therefore, source control of PCBs and selenium is recommended at a minimum for the protection of omnivorous mammals from the potential risk posed by PCBs and selenium downstream of the site.

5.3.2.9 Protection of carnivorous mammals

The food chain model and chronic hazard quotient calculations for carnivorous mammals are presented in Tables 74 to 76. Since this food chain model assumes that the red fox consumes 100 percent small mammals, and since the small mammals collected for this risk assessment were not analyzed for TAL metals, the risk from the bioaccumulative metals to carnivorous mammals could not be evaluated. The potential risk from the bioaccumulative organic contaminants, however, was evaluated. For location T1, when the maximum contaminant concentrations were used with their NOAELs in the model, it was determined that a potential risk is associated only with total PCBs. Similarly, when the mean contaminant concentrations and the NOAELs, as well as the maximum contaminant concentrations and the LOAELs, were used in the model, a potential risk was still calculated only for total PCBs. When the mean contaminant concentrations and the LOAELs were used, no risk was calculated from any bioaccumulative organic contaminant.

For location T2, when the maximum contaminant concentrations were used together with the NOAELs, a potential risk was calculated only for total PCBs. Similarly, when the mean contaminant concentrations were used together with the NOAELs, a potential risk was again only calculated for total PCBs. When both the maximum and the mean concentrations were used with the LOAELs, no risk was calculated from any of the bioaccumulative organic COPCs.

Finally, for location T3, no risk was calculated for any bioaccumulative organic COPC when any combination of mean or maximum contaminant concentrations with either the NOAELs or LOAELs was used in the model.

Since the total PCB dosage calculated from the model exceeded the chronic LOAEL for carnivorous mammals at location T1, the acute risk from PCBs to carnivorous mammals was also evaluated using the food chain model. The results of this evaluation are presented in Table 77 and indicate that no acute risk is posed by PCBs to carnivorous mammals utilizing the Bound Brook downstream of the Cornell-Dubilier Electronics site.

The lower boundary of the preliminary ecotoxicologically-based soil remedial goal for PCBs was determined to be 39 mg/kg, dry weight, for the protection of carnivorous mammals. Since the chronic LOAEL was not exceeded using the mean PCB concentrations at any location, the current soil PCB concentrations are already below the upper boundary (LOAEL) of the preliminary ecotoxicologically-based soil remedial goal range, thus the upper boundary was not determined. Furthermore, the hazard quotients that exceeded one using the mean PCB concentrations and the NOAEL were relatively low (1.9 and 8.9).

Overall, the results of the food chain evaluation indicate that a potential risk is posed to carnivorous mammals utilizing the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site from total PCBs. The lower boundary of the preliminary ecotoxicologically-based soil remedial goal range for PCBs was determined to be 39 mg/kg, dry weight, for the protection of carnivorous mammals. However, the mean soil PCB concentrations within the stream corridor downstream of the site are already currently within the preliminary ecotoxicologically-based remedial range.

5.3.2.10 A note about piscivorus mammals

Piscivorus mammals, such as mink and weasels, were not evaluated in this risk assessment because such animals were not expected to inhabit in great numbers the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site. However, it should be noted that if this trophic level had been evaluated, it is likely that a more significant chronic risk, and potentially an acute risk, would have been calculated for PCBs. First, this is because fish were found to contain overall higher levels of PCBs than other food items (crayfish and small mammals) used in this risk assessment. Since no other mammal was modeled to consume 100 percent fish, with the exception of the omnivorous mammal at location A6, the PCB dosage of a piscivorus mammal would be expected to be higher than the two mammals evaluated in this risk assessment. Second and more important, it is well documented that mink is the most sensitive mammal to PCBs. The chronic toxicity values used to evaluate the potential risk of PCBs to omnivorous and carnivorous mammals were derived from studies in which mink were used because no appropriate studies were located in which the mammalian measurement endpoints (raccoon or red fox) were directly evaluated for PCB toxicity. However, the acute toxicity values that were used to evaluate the acute risk of PCBs to omnivorous and carnivorous mammals were derived from acute toxicity studies using the raccoon. If a piscivorus mammal had been evaluated for acute risk posed by PCBs, a much lower acute toxicity reference value for mink would have been used, due to the greater sensitivity of mink to PCBs. This would thus have resulted in a much higher acute hazard quotient, probably greater than one.

5.4 Uncertainty Analysis

5.4.1 General Overview of Uncertainty Analysis

There are factors inherent in the risk assessment process that contribute to a level of uncertainty that must be considered when interpreting the results of a risk assessment.

Major sources of uncertainty arise from natural variability in biological and chemical systems, the introduction of error in the risk assessment process, and the presence of data gaps.

Natural variability is an inherent characteristic of ecological receptors, their stressors, and their combined behavior in the environment. Biotic and abiotic parameters in these systems may vary to such a degree that the exposure to ecological receptors in two identical conceptual models may differ temporally and spatially. Factors that contribute to temporal and spatial variability may be differences in an individual organism's behavior (within the same species), changes in the weather or ambient temperature, unanticipated interference from other stressors, differences between microenvironments, stochasticity, and numerous other factors. Thus, the conservative nature of this risk assessment assumes that the highly variable environmental conditions and the behavior of organisms and their stressors are interacting in such a manner that allows the contaminants to move freely through the identified exposure pathways, and to produce the same effects identified in the exposure profile.

Uncertainty associated with natural variability also arises from the use of literature toxicity values in which a study has examined a single species/single contaminant system under highly controlled conditions. If conducted in a laboratory, these studies do not take into account the effects of the environmental factors and other stressors that are present in natural systems. These factors may have synergistic, antagonistic, or neutral effects upon the receptor-contaminant interaction. Point estimates of exposure such as NOAELs, LOAELs, LD50s, and mathematical means that are presented in the literature also have an inherent variability, which is by default incorporated into the risk assessment.

In addition, uncertainty associated with natural variability is introduced from the use of literature values for soil, sediment, water, and food ingestion rates, dietary compositions, and body weights. These values reported in the literature are from studies that may have been conducted at a certain time of year or in a certain location that does not necessarily give an accurate representation of the life histories of the species assessed at the site under consideration in the risk assessment.

Error may be introduced into the risk assessment through the use of invalid assumptions in the conceptual model. Conservative assumptions were made in light of the uncertainty associated with the risk assessment process (e.g., natural variability). Conservative assumptions were used to minimize the possibility of concluding that risk is not present when a threat actually does exist (i.e., the elimination of false negatives). While there is uncertainty associated with each conservative assumption used, this consistent selection process assures that the uncertainty associated with this type of error will err on the side of a protective outcome.

This risk assessment does not examine the contribution of dermal absorption, transfer across epithelial membranes, or inhalation exposure as part of the exposure pathway. In contrast to the use of conservative assumptions, the error introduced into this risk assessment by the omission of these routes of exposure may err on the side of a less protective outcome. The relative contribution of this error to alter the outcome of the risk assessment is unknown at this time.

Methodological problems in the literature reviewed for obtaining life history and toxicity information also introduce uncertainty into a risk assessment. Attempts were made to avoid using literature that was questionable. However, if no other sources of information existed, this error was incorporated into the risk assessment if the data were used.

Data gaps were defined here as the incompleteness of data or information upon which the risk assessment was based. Specifically, these may be an incomplete contaminant data set, missing pieces of life history information, and the absence of toxicity-based literature for the receptor of concern.

Life history information and literature values for the toxicity of the contaminants of concern were not always available for all of the receptor species. By using closely related species, it was possible to make risk estimates. In reality, however, the information may vary substantially among species, thereby introducing another source of uncertainty.

In cases where a toxicity value has been converted by a factor of 10, the uncertainty associated with the absence of a directly relevant literature value was compounded by the uncertainty associated with a subjective mathematical adjustment.

5.4.2 Site-Specific Uncertainty Analysis

The results of the uncertainty analysis for the ecological risk assessment of the Cornell-Dubilier Electronics Superfund site are discussed next.

Based on the results of the sediment toxicity evaluations, contaminants were identified that potentially pose a risk to benthic invertebrate community structure and function. It could not be determined which of these contaminants or combinations of contaminants had definitively caused the observed toxicity.

Since aquatic and terrestrial toxicity tests were not conducted for this risk assessment, the potential risk of the COPCs that were detected in water and soil, and that either exceeded their benchmarks in the screening-level risk assessment or had no benchmark, could not be determined for these matrices. Therefore, the aquatic and terrestrial risk of these contaminants is uncertain.

Acceptable studies on the dietary toxicity of many of the bioaccumulative COPCs to many of the measurement endpoint species used in this risk assessment were not found. Therefore, dietary toxicity studies for surrogate receptors were used. An assumption was thereby made that the use of toxicity studies from surrogate receptors provides a similar and conservative approach to estimating the dietary exposure effects levels for the measurement. This was a source of additional uncertainty in the risk calculations for all of the measurement endpoints.

Uncertainty was also introduced into this risk assessment because the digestive tracts of forage fish were removed during processing for whole body analyses. In some fish species, the majority of the body fat is associated with the intestinal tract. Therefore, it is possible that a relatively large proportion of the lipid-soluble contaminants of concern may have been removed during processing of forage fish. This may have resulted in an underestimation of the lipid-soluble contaminant dosages, and thus hazard quotients, calculated using the piscivorus bird and omnivorous mammal food chain models.

Another source of uncertainty results from the assumptions that were made concerning the dietary composition of the selected measurement endpoints. For the omnivorous mammal (the raccoon), it was assumed that 50 percent of their diet consists of crayfish, and the other 50 percent consists of fish, the food items that were collected at the site. Similarly, for the carnivorous mammal (the red fox) it was assumed that 100 percent of its diet consists of small mammals, specifically white-footed mice. For insectivorous birds (the red-winged blackbird), it was assumed that 100 percent of their diet consists of crayfish, which were chosen to represent insects for the purposes of the food chain model for insectivorous birds. For omnivorous birds (the mallard duck), it was assumed that 100 percent of their diet consists of crayfish, and finally, for piscivorus birds (the green heron), it was assumed that 100 percent of their diet consists of fish. The diets of these species are known to be more varied in reality compared with the assumptions used here. However, the actual diets of these species within the Bound Brook stream corridor, as well as the degree of contamination in their actual diets, are unknown. This introduced uncertainty in the calculated contaminant dosages used in the hazard quotient calculations.

Food and water ingestion rates for red-winged blackbird and the green heron could not be found in the literature. For the red-winged blackbird, a food ingestion rate for a similar species was used. For the green heron, a regression equation for food ingestion that was found in the literature was used. To estimate water ingestion rates for these species, an allometric equation was used in each case. Since these ingestion rates are estimates rather than reported values, an additional level of uncertainty is introduced into the hazard quotient calculations for these measurement endpoints.

Since all area use factors were assumed to be one for all receptors evaluated in the food chain model, and since the actual area use factors are potentially less than one for many of the receptors, uncertainty was introduced into the determination of the contaminant dosage calculated in the food chain model. This introduces additional uncertainty into the hazard quotients calculated using the food chain models.

Sediment ingestion rates for the green heron could not be found in the literature. Therefore, estimated sediment ingestion rates were calculated based on reported dietary compositions and amounts of sediment/soil entrained in the digestive systems of prey items. In some cases, information on the entrainment of sediment/soil was unknown for certain prey items. Therefore, it was assumed that the dietary composition of the species in question consisted only of those species for which sediment/soil entrainment information had been reported. It was also assumed that the amount of sediment/soil entrained in prey items remained constant over time. These assumptions introduced uncertainty into the calculation of risk for the green heron.

Sediment ingestion rates for the red-winged blackbird could also not be found in the literature. Due to the feeding behavior of this bird, it was assumed that it does not ingest any sediment. Therefore, this route of exposure, if it exists, was not taken into consideration. However, it is conceivable that certain behavioral patterns of the red-winged blackbird could contribute to incidental sediment ingestion. Such behavior might include dust baths and preening, ingestion of grit, and sediment adhered to prey items. Because these routes of sediment ingestion were not considered for the red-winged blackbird, additional uncertainty was introduced into the hazard quotients for this assessment endpoint.

Most of the toxicity values in the literature from chronic exposure studies were reported as a concentration of the contaminant of concern in food. This concentration had to be converted to the appropriate dosage units (mg/kg BW/day) for the food chain model by multiplying this value by the food ingestion rate and dividing by the body weight of the test animals. If the study in question did not report body weights and/or ingestion rates for the test animals, they were chosen from the literature or, in the case of ingestion rates, sometimes allometric equations had to be used. This introduced uncertainty in the NOAEL and LOAEL values, and thus in the hazard quotients for the risk characterization. Additionally, in some cases, body weights and/or ingestion rates were only available for adults, and were therefore used even if the study was started when the test animals were newly hatched or young. This may have introduced additional uncertainty into the risk characterization process.

In the food chain model, the lowest reported body weights for adults and the highest reported ingestion rates were used in each case. Therefore, the dosage calculated may have been overestimated, thereby causing the hazard quotients to be overestimated for the measurement endpoint in question. However, the purpose of these assumptions was to provide a conservative estimate of the hazard quotient so as to protect the more sensitive species that fall within the assessment endpoint category (e.g., insectivorous birds). Nonetheless, these conservative assumptions introduce additional uncertainty into the risk characterization process.

In some cases, toxicity values in the literature were derived from data for which dosages were only reported as dry weight, and the authors did not give enough information to convert them to wet weight. Therefore, it was assumed that the food administered in these studies consisted of 1/3 solids to convert the dosages to wet weight. This assumption introduced additional uncertainty into the hazard quotient calculations.

In the food chain model, it was assumed that the contaminants are 100 percent absorbed upon ingestion and that the contaminants are not metabolized or excreted over the lifetime of the receptor. Therefore, the exposure dosages calculated in the food chain model may have been overestimated, thereby overestimating the hazard quotients. However, since the toxicity values obtained from the literature were based on applied dosages, rather than absorbed or assimilated dosages, this discrepancy theoretically cancels out in the hazard quotient equation. Nonetheless, this was an additional source of uncertainty in the hazard quotients calculated using the food chain model.

To assess the potential risk of bioaccumulative COPCs, the concentrations of contaminants that belong to a class of chemicals (e.g., PCBs) were summed and treated as a total contaminant concentration for that class. In determining toxicity reference values for these contaminant classes, the lowest appropriate toxicity value was chosen to represent the toxicity of the entire class of that type of contaminant. In doing so, it was assumed that the total concentration of each class of contaminant consisted entirely of the most toxic member of that class. This introduced additional uncertainty into the hazard quotient calculations.

In the food chain models for fish-eating receptors, the mean fish contaminant concentrations were calculated from whole body forage fish (pumpkinseed) data because this was the only species of fish for which whole body concentrations were analyzed. In addition to the analysis of whole body pumpkinseed, fillets were also taken and analyzed from pumpkinseed and many other species of fish to represent edible fish tissue for the purposes of a separate human health risk assessment. This fillet data set was combined with the whole body pumpkinseed data set to determine the maximum contaminant concentrations in fish for the purposes of the food chain models. Therefore, it was assumed that this combined data set (including the fillet tissue) is a representive data set to determine the maximum fish tissue concentration that a fish-consuming receptor would ingest. This introduced additional uncertainty into the calculation of the contaminant dosages in the food chain models for fish-consuming receptors, and thus introduced additional uncertainty into the associated hazard quotient calculations.

When comparing fish whole body tissue residue levels to those in the literature that are associated with toxicity in fish, only the residue levels for forage fish (pumpkinseeds) could be used for these comparisons, since pumpkinseeds were the only fish for which whole body analyses were conducted. Therefore, the risk of the COPCs evaluated in this risk assessment to other species of fish within the Bound Brook study area was not evaluated and is therefore uncertain.

No information could be found on the toxicity of whole body tissue levels in crayfish of methoxychlor, dieldrin, total endrin, total heptachlor, total DDT, arsenic, cadmium, lead, mercury, and selenium. Therefore, the risk posed by these COPCs to crayfish within the Bound Brook study area is uncertain.

No information could be found on the toxicity of whole body tissue levels in fish of methoxychlor, dieldrin, total endrin, total heptachlor, total DDT, arsenic, cadmium, and lead. Therefore, the risk posed by these COPCs to fish within the Bound Brook study area is uncertain.

For chlordane, the fish and crayfish tissue residue threshold values reported in the literature were reported as lipid-normalized concentrations. For the purposes of comparing these threshold values to measured tissue concentrations in the fish and crayfish collected for this risk assessment, which were not lipid-normalized, an overall mean percent lipids for both crayfish and fish was calculated from the analytical results of the crayfish and fish collected from the site. The resulting mean percent lipids were assumed to be representative of crayfish and fish, and were used to convert the lipid-normalized values reported in the literature to non-lipid-normalized values for the hazard quotient calculations. This introduced uncertainty into the chlordane hazard quotient calculations using measured whole body tissue levels of fish and crayfish.

For selenium, the fish tissue residue threshold values reported in the literature were reported as dry weight concentrations. For the purposes of comparing these threshold values to measured tissue concentrations in the fish collected for this risk assessment, which were in wet weight, an overall mean percent solids for fish was calculated from the analytical results of the fish fillets collected from the site. The fish fillets were used, rather than whole body forage fish (pumpkinseeds), because the percent solids were only analyzed for the fish fillets. The resulting mean percent solids from the fillet tissue were assumed to be representative of percent solids in the whole body fish reported in the literature, and were used to convert the literature dry weight values to wet weight values for the hazard quotient calculations. This introduced uncertainty into the selenium hazard quotient calculations using measured whole body tissue levels of fish.

No information could be found on the toxicity of whole body tissue concentrations in mammals of total chlordane, methoxychlor, dieldrin, total endrin, total heptachlor, total DDT, total PCBs, arsenic, cadmium, lead, mercury, and selenium. Therefore, the risk posed by these COPCs to small mammals within the Bound Brook stream corridor study area is uncertain.

Frogs were not available in sufficient quantities for collection and analysis. In addition, due to delays in the development of the frog embryo assay, a non-standardized toxicity test, this assay was not able to be performed as originally intended. Therefore, the risk of the COPCs to amphibians within the Bound Brook corridor downstream of the Cornell-Dubilier Electronics site is uncertain.

Crayfish were not present during the time of collection at location A6. Therefore, the risk of the bioaccumulative COPCs to crayfish-consuming measurement endpoints at location A6 is uncertain.

Emergent aquatic insects were not present at the site in sufficient quantities for collection and analysis. Therefore, crayfish were assumed to be representative of these insects in the food chain model for insectivorous birds. This assumption introduces uncertainty into the determination of risk of the bioaccumulative COPCs to insectivorous birds within the Bound Brook study area.

The small mammals collected for the purposes of this risk assessment were not analyzed for TAL metals. Since carnivorous mammals (the red fox) were assumed to consume 100 percent small mammals, the risk posed by the inorganic bioaccumulative COPCs evaluated in this risk assessment to carnivorous mammals within the Bound Brook study area is uncertain.

5.5 Conclusions from the Ecological Risk Assessment

5.5.1 Protection of the structure and function of the stream

The results of this risk assessment indicate that the structure and function of the stream communities downstream of the Cornell-Dubilier Electronics site are at risk from chemical contamination. First, a risk is posed to the benthic community and is potentially due to a variety of VOCs and BNAs, silver, calcium, copper, vanadium, zinc, and dieldrin. The fish within the stream were determined to be potentially at risk from exposure to selenium and PCBs, but the risk posed by the other bioaccumulative COPCs could not be determined. Birds utilizing the stream were determined to be potentially at risk from lead, PCBs, total endrin, total chlordane, and total DDT. Finally, a potential risk to omnivorous mammals using the stream was found to be posed by methoxychlor, arsenic, mercury, PCBs and selenium.

5.5.2 Protection of the structure and function of the stream corridor

The results of this risk assessment indicate that the structure and function of the stream corridor downstream of the Cornell-Dubilier Electronics site are at risk from chemical contamination. First, birds utilizing the stream corridor were determined to be potentially at risk from lead, PCBs, total endrin, total chlordane, and total DDT. A potential risk to omnivorous mammals using the stream was found to be posed by methoxychlor, arsenic, mercury, PCBs and selenium. Finally, a potential risk to carnivorous mammals was also found to be posed by PCBs.

5.5.3 Protection of fish communities

The results of two stream bioassessments previously performed by the U.S. EPA (1992, 1993b) have indicated that the fish communities within the Bound Brook adjacent to and downstream of the Cornell-Dubilier Electronics site have been adversely affected. The results of this risk assessment indicate that this impairment may be due, at least in part, to the contamination within the stream. Specifically, selenium and PCBs were found to pose a potential risk to fish, since selenium and PCB concentrations in the fish were found to be higher than those found in the literature to be associated with toxic effects. Therefore, selenium and PCBs may contribute to the observed population-level effects. In addition, since the risk from methoxychlor, dieldrin, total endrin, total heptachlor, total DDT, arsenic, cadmium, and lead to fish could not be determined using this method of evaluation, it is possible that any of these contaminants may also pose a potential risk to fish in the Bound Brook.

5.5.4 Protection of benthic invertebrate communities

The results of a stream bioassessment previously performed by the U.S. EPA (1993c) has indicated that the macroinvertebrate communities within the Bound Brook adjacent to and downstream of the Cornell-Dubilier Electronics site have been adversely affected. In addition, toxicity was observed in sediments collected from one downstream location. The results of this risk assessment indicate that this impairment may be due, at least in part, to the contamination within the stream. Specifically, a potential risk is posed to benthic invertebrate community structure and function from methylene chloride, acetone, toluene, carbon disulfide, benzidine, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, di-n-octyl phthalate, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, benzo(ghi)perylene, silver, calcium, copper, vanadium, zinc, and dieldrin.

5.5.5 Protection of insectivorous birds

The results of this risk assessment indicate that a potential risk is posed to insectivorous birds from lead, total endrin, and total PCBs. Although no preliminary ecotoxicologically-based sediment remedial goals could be established for these contaminants to protect insectivorous birds, calculated hazard quotients were relatively low, and contaminant concentrations in sediment would already be within the preliminary remedial goals had they been established. Furthermore, the data indicate that the sediment lead concentrations downstream of the site are not entirely site-related since the mean crayfish concentration at the reference area was greater than the mean lead concentrations in crayfish from all locations evaluated using the insectivorous bird model.

5.5.6 Protection of omnivorous birds

The results of this risk assessment indicate that a potential risk is posed to omnivorous birds by lead. Although the lower boundary of the preliminary ecotoxicologically-based sediment remedial goal range was determined to be 28 mg/kg, dry weight, to protect omnivorous birds, this concentration is much lower than the mean sediment concentration measured at the reference area (A9). This indicates that the sediment lead concentrations downstream of the site are not entirely site-related. Furthermore, the mean sediment lead concentrations downstream of the site are currently already within the preliminary ecotoxicologically-based remedial goal range.

5.5.7 Protection of piscivorus birds

The results of this risk assessment indicate that a potential risk is posed to piscivorus birds utilizing the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site from total chlordane, total endrin, total DDT, total PCBs, and lead. However, since chlordane, endrin, DDT or any of their derivatives were not detected in any of the sediment samples collected from the Bound Brook downstream of the site, with the exception of one sample from location A7, in which 0.03 mg/kg of DDD was detected, these three pesticides were deemed not to be site-related and therefore, no preliminary ecotoxicologically-based remedial goals were established for these pesticides. For lead, the lower boundary of the preliminary ecotoxicologically-based sediment remedial goal range was determined to be 250 mg/kg, dry weight, for the protection of piscivorus birds. However, the mean sediment lead concentrations downstream of the site are already currently within and at the low end (close to the NOAEL) of the preliminary ecotoxicologically-based remedial range. For PCBs, a preliminary ecotoxicologically-based sediment remedial goal range could not be determined because the mean sediment PCB concentrations did not correlate with the resulting hazard quotients. Therefore, source control of PCBs is recommended at a minimum for the protection of piscivorus birds from the risk posed by PCBs downstream of the site.

5.5.8 Protection of omnivorous mammals

The results of this risk assessment indicate that a potential risk is posed to omnivorous mammals utilizing the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site from methoxychlor, total PCBs, arsenic, mercury, and selenium. However, since methoxychlor was not detected in any of the sediment samples collected from the Bound Brook downstream of the site, this pesticide was deemed not to be site-related and therefore, no preliminary ecotoxicologically-based remedial goal was established for methoxychlor. For arsenic and mercury, a preliminary ecotoxicologically-based remedial goal was also not established because a hazard quotient of greater than one was only established for these contaminants when the maximum contaminant concentrations were used. Therefore, their sediment concentrations are already below what would have been the preliminary ecotoxicologically-based sediment remedial goal had one been established. For PCBs and selenium, a preliminary ecotoxicologically-based sediment remedial goal range could not be determined because the mean sediment PCB and selenium concentrations did not correlate with their resulting hazard quotients. Therefore, source control of PCBs and selenium is recommended at a minimum for the protection of omnivorous mammals from the risk posed by PCBs and selenium downstream of the site.

5.5.9 Protection of carnivorous mammals

The results of this risk assessment indicate that a potential risk is posed to carnivorous mammals utilizing the Bound Brook stream corridor downstream of the Cornell-Dubilier Electronics site from total PCBs. The lower boundary of the preliminary ecotoxicologically-based soil remedial goal range was determined to be 39 mg/kg, dry weight, for the protection of carnivorous mammals. The mean soil PCB concentrations within the stream corridor downstream of the site are already currently within the preliminary ecotoxicologically-based remedial range.

5.5.10 Overall recommendations from the ecological risk assessment

The most significant risk determined by this risk assessment is posed by those contaminants that resulted in a hazard quotient greater than one using the mean contaminant concentrations and the LOAEL in the food chain models. This occurred for total PCBs using the omnivorous mammal and piscivorus bird models and for selenium using the omnivorous mammal model. However, for these two contaminants, a preliminary ecotoxicologically-based sediment remedial goal could not be determined because sediment concentrations did not correlate with their resulting hazard quotients in the food chain models. Therefore, for these contaminants, source control is recommended at a minimum to minimize risk to the assessment endpoints evaluated in this risk assessment.

A note should be made about the site-relatedness of selenium and PCBs. When the extent of contamination was evaluated, it became evident that other sources, in addition to the Cornell-Dubilier Electronics site, probably exist for these two contaminants. In the case of PCBs, this is evident because PCBs were detected in fish collected from Spring Lake (Figure 3 and Table 37). Since it is unlikely that fish could migrate upstream from the Bound Brook into Spring Lake due to the existence of a high retaining wall (spillway) at the downstream end of the lake, it is evident that another source of PCBs probably exists upstream of Spring Lake. Nonetheless, the Cornell-Dubilier Electronics site appears to be a significant source of PCBs due to the high PCB concentrations detected in the sediment samples collected adjacent to the site (location A1) and the rapid decrease in PCB concentrations at locations further downstream of the site.

With regard to selenium, the reference area (A9) contained a mean sediment concentration of 1.8 mg/kg, dry weight, of selenium, which is greater than the mean sediment concentrations at both locations A4 and A5, where a risk from selenium (above the LOAEL) was calculated. Therefore, an additional source of selenium potentially exists along the Bound Brook upstream of the Cornell-Dubilier Electronics site. Nonetheless, the Cornell-Dubilier Electronics site may also be a potential source of selenium because the concentrations of selenium detected in the samples collected adjacent to (location A1) and immediately downstream of (locations A2 and A3) the site are greater than the concentrations detected at the reference (location A9). Then, the sediment selenium concentrations generally decrease further downstream of location A3, although this effect is not nearly as pronounced as it is for PCBs.

Since no sediment remedial goal could be established for either of these contaminants, and since the Cornell-Dubilier Electronics site appears to be a significant source of PCBs and a potential source of selenium, this risk assessment indicates that source control of PCBs and selenium at the Cornell-Dubilier Electronics site should be implemented at a minimum to decrease the risk posed by PCBs and selenium to the assessment endpoints evaluated in this risk assessment.

6.0 PRESENTATION OF EDIBLE FISH DATA FOR THE ASSESSMENT OF RISK TO HUMAN HEALTH

6.1 Project Scope

The objective of this phase of the project was to collect fish tissue data relevant to human health evaluations for the Bound Brook adjacent to and downstream of the Cornell-Dubilier Electronics site. A reference station was established upstream of the site that exhibited similar habitat as the potentially impacted areas. Sample stations were selected based on similar habitat between sample stations. The fish were analyzed for target compound list (TCL) pesticides/PCBs and target analyte list (TAL) metals. Both bottom feeding and predatory fish species were collected and analyzed for chemical contaminants. The results were provided to the U.S. EPA Region II for the purposes of human health exposure evaluation. The results of the metals analyses of fish tissue are discussed in Section 3.3.8.1 for Phase II data and 3.4.2.1 for Phase III data, and are not included as part of the results for the human health evaluation.

6.2 Fish Collection

Fish were collected in conjunction with U.S. EPA Region II from a total of twelve locations from the Bound Brook, New Market Pond, and Spring Lake using electrofishing techniques (Figures 3 and 4). The objective of the sampling was to collect edible-sized bottom feeding fish (carp and white suckers) and predatory fish (sunfish, bullhead, and largemouth bass) of similar size between the sample locations. A maximum of three fish were collected of each species from each location but not all species were collected at all locations (e.g., bullhead were only collected at A5, A11, A12, and A14).

The sampling crew taxonomically identified the fish, measured the length and weight of the fish, and performed a gross pathology evaluation. The fish were prepared following the U.S. EPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (1993a). Fish were scaled prior to filleting (for catfish, the skin was removed prior to analysis). Each fillet sample represented a single fish; no sample compositing was required to meet analytical mass requirements. The fillets were weighed, then wrapped in aluminum foil, placed in a plastic bag, and frozen. Fish were delivered to the REAC Biological Assessment Laboratory in Edison, NJ for chemical analysis. Fish tissue was analyzed for TAL metals, TCL pesticides and PCBs, percent lipids, and percent moisture. The data will be used by Region II U.S. EPA for a human health risk assessment.

6.3 Results

Edible fish were collected from ten locations adjacent to and downstream of the Cornell-Dubilier Electronics site, as well as from an upstream reference area and from Spring Lake (Figures 2 and 3). Complete analytical results are included in Appendix C, Final Analytical Report. Tables 78 and 79 provide summary statistics (mean, coefficient of variability [cv], minimum, and maximum) for each compound in each species at each location for PCBs and pesticides, respectively.

6.3.1 Polychlorinated Biphenyls

Aroclors 1248 and 1254 were detected in all fillet samples in all species (Table 28 for Phase II data and Table 37 for Phase III data). Generally, Aroclor 1254 was detected at higher concentrations than Aroclor 1248. For the purposes of the human health evaluation, the U.S. EPA (1993a) recommends that PCBs be reported as the sum of all Aroclors analyzed, with a value of one-half the detection limit assigned to those Aroclors not detected. For this study, total PCBs represents the sum of Aroclor 1248 and 1254 only, and does not include the addition of the other Aroclors that were not detected.

The results (mg/kg, wet weight) indicate that the highest PCB concentrations are located in the length of the Bound Brook that extends from the reference area downstream to New Market Pond. The mean total PCB concentrations in white sucker fillet ranged from 3.9 to 9.5 mg/kg, wet weight. White sucker were also collected from Spring Lake, and downstream of New Market Pond to the Raritan River. The mean concentrations of total PCBs in white sucker for the locations in this length of the Bound Brook ranged from 0.4 to 2.0 mg/kg, wet weight. The same trend is noted for the mean PCB concentrations in pumpkinseed. The mean total PCB concentrations in fillets from pumpkinseeds collected from the reference area downstream to New Market Pond ranged from 1.9 to 5.5 mg/kg, wet weight. The mean total PCB concentrations in fillets from pumpkinseeds collected downstream of New Market Pond to the Raritan River ranged from 0.2 to 0.9 mg/kg, wet weight.

No trends were apparent for largemouth bass and bullhead due to the limited number of samples collected from each location.

The concentrations of total PCBs in carp do not follow the same trend as the pumpkinseed and white sucker. The lowest concentration of PCBs were noted in carp collected from the Reference Area (A9) and from Spring Lake (A10). Both of these locations are up gradient of the site. The highest mean concentrations of total PCBs in carp fillet were detected in the fish collected from New Market Pond, locations A5 and A6, (22 to 24 mg/kg, wet weight) and from two of the downstream locations, locations A12 and A13, (27 to 31 mg/kg, wet weight).

6.3.2 Pesticides

Nine pesticides (heptachlor epoxide, g-chlordane, a-chlordane, p, p'-DDE, p, p'-DDD, endrin, endrin aldehyde, dieldrin, and methoxychlor) were detected in the edible fish samples (Table 28 for Phase II data and Table 37 for Phase III data). Methoxychlor was mostly likely a laboratory contaminant since it was detected in the laboratory blanks and in only one sample at a concentration near the detection limit.

The compound 4,4'-DDE was the most frequently detected pesticide found in the fish fillets. Approximately 85 percent of the fish captured contained detectable levels of this pesticide. However, there are no distinct trends among species with the exception that carp contained the highest concentrations compared to the other species collected. When the mean concentrations of 4,4'-DDE were calculated for each location across all species, trends among the locations were observed. The mean 4,4'-DDE concentration in edible fish tissue was low at the two locations up gradient of the site (A9 and A10), increased toward locations A1 and A2, and drastically decreased toward location A5. The mean 4,4'-DDE tissue concentration then increased again at location A6 (the upstream New Market Pond location) and gradually decreased from there toward location A14. Heptachlor epoxide was detected most frequently in the samples collected from the reference area downstream to New Market Pond (85 percent). The frequency of detection of this pesticide drops below New Market Pond and heptachlor epoxide is only detected in one pumpkinseed collected at location A12. This pesticide was detected in five of the eleven fish collected from Spring Lake.

Chlordane was detected in samples collected both upstream and downstream of New Market Pond. However, this pesticide was only detected in white sucker, carp, and catfish. It should be noted that technical grade chlordane was detected in three carp and three white suckers collected from Spring Lake. Technical grade chlordane is defined as the presence of both a-chlordane and g-chlordane. It should also be noted that dieldrin was only detected in four fish, and these fish were captured in Spring Lake.

Endrin aldehyde was only detected in largemouth bass, carp, white sucker, and pumpkinseed collected from New Market Pond. Endrin was only detected in one carp collected from the Bound Brook (A12) downstream of New Market Pond.

6.4 Discussion

In general, the highest PCB and pesticide concentrations were found in the carp, followed by white sucker, pumpkinseed, and largemouth bass. The concentrations of these compounds may be linked to the percent lipids in each of these species. A review of the lipid content indicates that carp have the highest lipid content (25 percent) followed by white sucker (11 percent), bullhead (6 percent), pumpkinseed (5 percent), and largemouth bass (3 percent). Organochlorine pesticides are usually insoluble in water but are very soluble in lipids. This allows these compounds to be stored in fatty tissue, with the higher concentrations found in those species with a higher lipid content.

With the exception of carp, the highest PCB concentrations were noted in the fish collected in the Bound Brook from the reference area downstream to New Market Pond, indicating that the Cornell-Dubilier Electronics site is a significant source of PCBs in the Bound Brook. On the other hand, the concentration of PCBs were higher in carp collected downstream of New Market Pond. This may be due to several factors. The size (and therefore the age) of the fish may play an important role in the accumulation of organochlorine pesticides and PCBs. The older the fish, the longer the exposure duration and the higher the concentration that may accumulate in the tissue. The carp collected below New Market Pond were larger than those collected upstream of New Market Pond. Another potential explanation for why PCBs in carp were higher in fish collected downstream of New Market Pond is that there may be another source of PCBs, in addition to the Cornell-Dubilier Electronics site, downstream of New Market Pond. This does not appear likely, however, because of the low levels of PCBs found in the other fish species collected below New Market Pond. Another explanation is that there were a limited number of carp collected. The limited number of fish allows for a wide range in the standard deviation, and there is some overlap with the concentrations of PCBs detected in fish throughout the extent of the fish sampling effort.

Of particular note is the presence of PCBs and many pesticides in the fish collected from Spring Lake. Since this lake receives water from a different drainage, it appears as if another source, in addition to the Cornell-Dubilier Electronics site, may be contributing to the contamination within the Bound Brook. Nevertheless, the Cornell-Dubilier Electronics site appears to be a significant source of PCBs detected in the edible fish tissue collected from the Bound Brook downstream of the site.

7.0 OVERALL CONCLUSIONS

7.1 Nature and Extent of Contamination

When the nature and extent of contamination were evaluated in this study, two overall conclusions were drawn:

- Many contaminants are present at relatively high levels adjacent to and/or immediately down gradient of the site. These concentrations progressively decrease toward location A14, near the confluence of the Green Brook and the Raritan River, with the exception of a sharp increase either immediately upstream of New Market Pond or within New Market Pond. The increase in concentrations of many contaminants immediately upstream or within New Market Pond may be the result of a slower rate of flow, resulting in greater deposition of particles onto which the contaminants are adsorbed. Regardless, the high concentrations adjacent to and directly downstream of the Cornell-Dubilier Electronics site indicate that the site is the primary source of many of the contaminants of concern within the section of the Bound Brook corridor investigated for this study.

- The presence of contaminants up gradient of the site (at the reference and in Spring Lake) suggest that, in addition to the Cornell-Dubilier Electronics site, other sources of contamination exist within the Bound Brook stream corridor.

7.2 Ecological Risk Assessment

The results of the ecological risk assessment resulted in the following overall conclusions:

- The structure and function of the communities within the Bound Brook and its stream corridor adjacent to and downstream of the Cornell-Dubilier Electronics site are at risk from chemical contamination. First, a risk is posed to the benthic community and is potentially due to a variety of VOCs and BNAs, silver, calcium, copper, vanadium, zinc, and dieldrin. The fish within the stream were determined to be at risk from exposure to selenium and PCBs; the risk posed to fish by the other bioaccumulative COPCs could not be determined. Birds utilizing the stream were determined to be at risk from lead, PCBs, total endrin, total chlordane, and total DDT. A risk to omnivorous mammals using the stream was found to be posed by methoxychlor, arsenic, mercury, PCBs and selenium. Finally, a risk to carnivorous mammals was also found to be posed by PCBs.

- Of the contaminants determined to pose a risk to the assessment endpoints evaluated in the risk assessment, the most significant risk is posed by those contaminants that resulted in a hazard quotient greater than one using the mean contaminant concentrations and the LOAEL in the food chain models. This occurred for PCBs using the omnivorous mammal and piscivorus bird models and for selenium using the omnivorous mammal model. However, for these two contaminants, a preliminary ecotoxicologically-based sediment remedial goal could not be determined because their sediment concentrations did not correlate with their resulting hazard quotients in the food chain models. In addition, it is probable that other sources, in addition to the Cornell-Dubilier Electronics site, exist and are contributing to the risk posed by these two contaminants. Therefore, source control at the Cornell- Dubilier site is recommended at a minimum to decrease risk to the assessment endpoints evaluated in the risk assessment.

7.3 Presentation of Data for Human Health

- In general, the highest PCB and pesticide concentrations were found in the carp, followed by white sucker, pumpkinseed, and largemouth bass. The concentrations of these compounds may be linked to the percent lipids in each of these species.

- With the exception of carp, the highest PCB concentrations were noted in the fish collected in the Bound Brook from the reference area downstream to New Market Pond. The concentration of PCBs was higher in carp collected downstream of New Market Pond. This is most likely due to the large size (and therefore age) of the carp collected below New Market Pond and the limited number of carp collected, resulting in high variability in the data.
- Of particular note is the presence of PCBs and many pesticides in the fish collected from Spring Lake. Since this lake receives water from a different drainage, it appears as if another source, in addition to the Cornell-Dubilier Electronics site, may be contributing to the contamination within the Bound Brook. Nevertheless, the Cornell-Dubilier Electronics site appears to be a significant source of PCBs detected in the edible fish tissue collected from the Bound Brook downstream of the site.

REFERENCES

Barnthouse, L.W., et al. 1986. *User's Manual for Ecological Risk Assessment.* Publication Number 2679, ORNL-6251. Environmental Services Division, Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. EPA. 1992. *Stream Bioassessment, Green Brook Drainage, New Jersey.* U.S. EPA Region II Ambient Monitoring Section. Environmental Services Divison. New York, New York.

U.S. EPA. 1993a. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, v.1. Fish Sampling and Analysis.* EPA/823-R-93/002. August 1993.

U.S. EPA. 1993b. *Stream Bioassessment, Bound Brook, New Jersey - [Fish].* U.S. EPA Region II Ambient Monitoring Section. Environmental Services Divison. New York, New York.

U.S. EPA. 1993c. *Stream Bioassessment, Bound Brook, New Jersey - [Macroinvertebrates].* U.S. EPA Region II Ambient Monitoring Section. Environmental Services Divison. New York, New York.

U.S. EPA. 1995. *Revised Region III BTAG Screening Levels.* U.S. EPA Region III BTAG. Technical Support Section. Philadelphia, PA.

U.S. EPA. 1996. *Screening Level Ecological Risk Assessment for Cornell-Dubilier.* U.S. EPA Region II. Surveillance and Monitoring Branch. 7 pp.

U.S. EPA. 1997a. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final.* EPA 540/R-97/006. OSWER 9285.7-25, PB97-963211. June 1997.

U.S. EPA. 1997b. *Removal Site Evaluation for the Cornell-Dubilier Electronics Site (AKA: Hamilton Industrial Park), South Plainfield, Middlesex County, New Jersey.* U.S. EPA Region II. 21 pp.

U.S. EPA. 1997c. *Bound Brook Sampling and Edible Fish Tissue Data Report, Cornell-Dubilier Electronics Site, South Plainfield, NJ.* U.S. EPA Office of Emergency and Remedial Response. 9 pp.

U.S. EPA. 1997d. *Final Work Plan, Cornell-Dubilier Electronics Site, South Plainfield, NJ.* 36 pp.